THE ECOLOGY OF THE IRISH STOAT

by

David Patrick Sleeman M.Sc.(Agr)

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Head of Department and Supervisor Professor Maire Mulcahy.

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ABSTRACT

The Irish stoat, Mustela erminea hibernica (Thomas and Barrett-Hamilton), has been regarded as an intermediate between the British stoat and the weasel. In this study Irish stoats, mainly from road casualties, were collected and studied. A small number were also live-trapped and radio-tracked. Thus information was gathered on the stoat's ecology, in particular its form (size and coat colours), reproduction, food habits, parasites, habitat utilisation mortality and predation.

The Irish stoats studied were clearly not intermediate in size between British stoats and weasels. They showed considerable size overlap with British stoats, and marked size variation within Ireland. It is argued that size of stoats is determined by food supply early in life. The ventral coat pattern of Irish stoats is apparently unique in the Palaearctic, being similar to that of some stoats found on the west coast of North America. It is argued that this is an example of parallel evolution resulting from adaptation to similar climatic conditions.

The stoats were reproductively active in spring and summer. Food consisted mainly of rabbits, but rats, birds, shrews mice and voles were also consumed. Mites were the most numerous ectoparasites, followed by lice, ticks and fleas. Damage by the parasitic nematode Skrjabingylus nasicola was found more frequently in female stoat skulls.

Stoats were frequently found in a variety of habitats, both open and wooded. Some of the radio-tracked stoats climbed trees. Dens used were often rat holes. Only one home range, that of a breeding female, was considered to have been accurately measured. It was 22 ha. in size. Mortality is known to have been caused by road accidents and domestic carnivores. It is argued that predation by raptorial birds is important to stoat populations. Results of this study are compared with information available from elsewhere.

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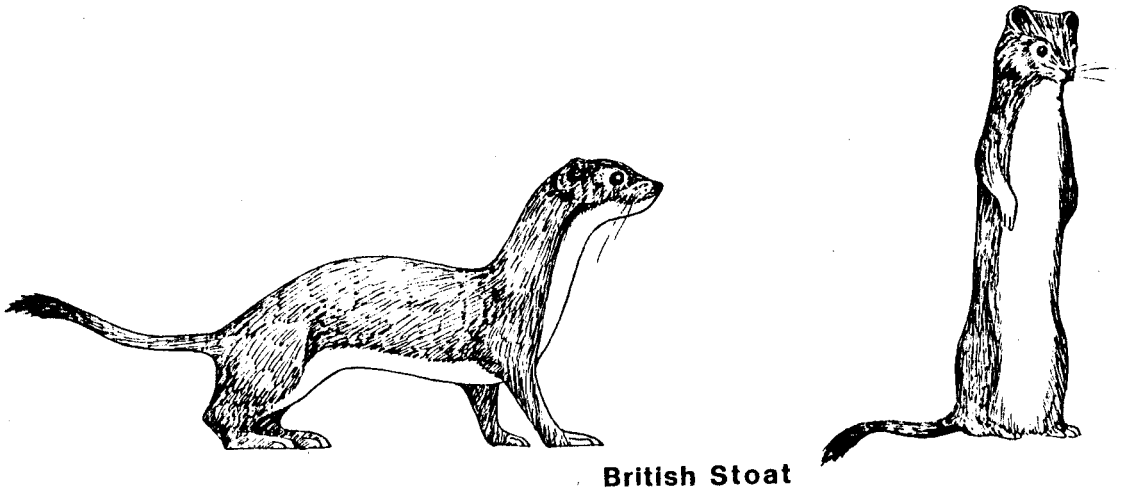
INTRODUCTION

1.1 THE IRISH STOAT - AN INTRODUCTION

Taxonomists are loosely described as 'splitters' and 'lumpers'. Splitters are those who seek to describe animal variation by naming new forms, lumpers are those who seek to simplify accounts of such variation and the resultant taxonomy. Around the turn of the century splitters were predominant and their efforts resulted in the description of numerous mammalian species and subspecies from these islands, most of which are now not accepted as valid (Dadd 1970; Matthews 1982). However one of these endemic subspecies, the Irish stoat is still accepted.

The Irish stoat was first described as a distinct form in 1895 by two splitters, Oldfield Thomas and Gerald Barrett-Hamilton (1895a & b). The original descriptions declared the Irish stoat to be a separate species Putorius hibernicus Thomas & Barrett-Hamilton, but the name was later changed to Mustela hibernica (Miller 1912). More recent workers have classified the Irish stoat as a subspecies Mustela erminea hibernica (Dadd 1970; Fairley 1971). It is known only from Ireland and the Isle of Man.

The Irish stoat is generally smaller than the British stoat, its dorsal coat is darker and the line between the dorsal brown and ventral white is irregular rather than regular (Fig.1). Its upper



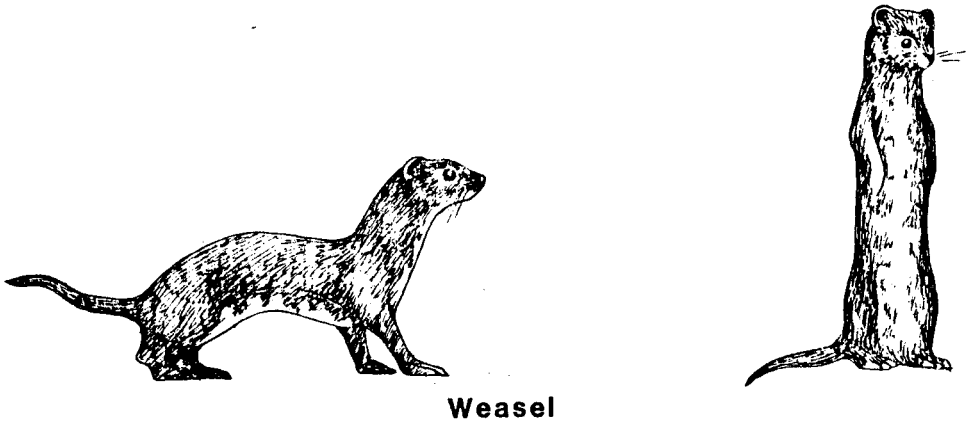


Figure 1. Idealised representation of coat colour and size of British stoat, weasel and Irish stoat

lips and ear tips are usually dark and its coat does not usually turn white in winter. It is evident that the extent and pattern of ventral whitening is similar in the Irish stoat and British weasel. However the tip of the tail of the Irish stoat is black, which is diagnostic of stoats (Fig.1).

It was the Irish stoat's size, and the similarity of its coat colour to that of weasels, that prompted the original describers of the Irish stoat, Thomas and Barrett-Hamilton to suggest that it was an intermediate between the weasel and stoat "... with some of the characters of each of the British species". Their puzzlement due to finding this animal is well recorded. Thomas (1895) called the existence of the Irish stoat as a "... locally recognisiable form..... a most astonishing fact, and one for which it seems almost impossible to offer a reasonable explanation". Similarly Barrett-Hamilton (1912) stated that the Irish stoat was "... the most mysterious of all our mammals".

Interest in natural history quickened in Ireland, as elsewhere, during the Victorian era (Fairley 1984). At the time, the discovery of the distinct Irish stoat aroused considerable surprise and curiosity (see above & Anon 1895). This probably accounts for some of the early publications involving Irish stoats (Brenan 1897; Longfield 1901; Scharff 1909; Barrett-Hamilton 1909; Pentland 1917).

This interest also led to live specimens being displayed at London Zoological Gardens in 1895 (Thomas 1895) and at Dublin Zoological Gardens in 1906. These specimens are now preserved in the British Museum (N.H.) (BMNo 39.7.60) and the National Museum, Dublin (NMI No 255.1906). Many of the museum specimens of Irish stoats now available were collected between 1895 and 1900, again probably as a result of the interest in the then new discovery.

Despite all this interest, published measurements of the animals' dimensions were, for many years, available only from two sources: the original description of the type specimen (Thomas & Barrett-Hamilton 1895b), and Miller's (1912) measurements of 44 animals. The measurement that is normally used to illustrate the size of stoats is skull length, which is known to correlate with overall body size. Miller (1912) included only ten skull measurements, of which three were from the Isle of Man, and six of the seven skull measurements from Ireland were from Ulster. This sample of skull measurements, biased as it is in favour of the small stoats that exist in Ulster was used by the ecologists Hutchinson (1959) (see Table 1) and Williamson (1972) to propose that the absence of the weasel from Ireland had influenced the size of the Irish stoat.

Dadd (1970) using available data, examined several of the British subspecies. He found considerable overlap in the size of British and

TABLE 1. SKULL MEASURMENTS USED BY HUTCHINSON (1959).

	Sympatric		Allopatic		Ratio when sympatric
Weasel *Mustela nivalis*	Britain	♂ 39.3	Mediterranean subspecies		
		♀ 33.6	(*boccamela*)	♂ 42.9	
				♀ 34.7	♂ 100:128
					♀ 100:134
			(*iberica*)	♂ 40.4	
				♀ 41.9	
Stoat *Mustela erminea*	Britain	♂ 50.4	Ireland		
		♀ 45.0	(*hibernica*)	♂ 46.0	
				♀ 41.9	

Irish stoats. However he concluded that the differences in coat colour (see above) were sufficient to make the Irish form a distinct subspecies.

Further measurements, again mainly from Ulster stoats, were published by Fairley (1971), who first suggested that stoats in the south of Ireland were larger than those in the north. This was subsequently confirmed by the discovery of a north/south cline in size by Fairley (1981). Such north/south size clines are also reported from Russia (Petrov 1962), Britain (E.Hardwood-pers.comm.) and Sweden (S.Erlinge-pers.comm.). Curiously the size clines reported in North American stoats and British weasels appear to go in the opposite direction (King 1977c; Ralls & Harvey 1985).

Other information on the biology of the Irish stoat is limited. Fairley (1971) also dealt with the Irish stoat's diet , ectoparasites and reproduction. A year's tunnel trapping in Co Kerry (Thompson & Fairley 1978) caught stoats in June, July and October and these appearances in traps were associated with the surges in stoat numbers reported by gamekeepers. More recently there have been two short notes on the Irish stoat, one on stoat remains on an off-shore island (Smiddy 1984) and one on a stoat eating fish (Devane 1984). Other literature, much of which is anecdotal, has been reviewed in a chapter on the Irish stoat in the two editions of James Fairley's An Irish Beast Book (1975,1984).

1.2 THE IRISH STOAT - AS AN EXAMPLE IN ECOLOGY

Since the turn of the century the emphasis of scientific interest has shifted from descriptive morphology to an interest in animal ecology and evolution. Central to the science of evolutionary ecology is the idea that animals compete with each other for limited resources. The study of such competition and its effects on animals has often drawn on island examples.

There are at present 28 species of terrestrial wild mammal in Ireland, 55 in Britain and about 150 in mainland Europe. This impoverished mammal fauna has important implications for Irish stoats. Firstly there are very few suitable small mammal prey species. In the past, before the advent of human introductions, there were only two i.e. the red squirrel Sciurus vulgaris L. and the pygmy shrew Sorex minutus L. (Table 37).

Human introductions have provided several suitable prey including mice, rats and rabbits. In 1964 the bank vole Clethrionomys glareolus (Schreber), a favoured prey of carnivores (Macdonald (1977), was found in Ireland (Claassens & O'Gorman 1965). It is regarded as a recent accidental human introduction and has now spread over much of south west Ireland (Fairley & O'Donnell 1970; Smal & Fairley 1978, 1984). [As there is only one species of shrew

and one species of vole in Ireland the terms shrew and vole are used hereafter to indicate the two species] The voles are so distributed (Fig. 17) that it was possible in this study to catagorise stoats from vole and non-vole areas.

The second implication of the impoverished Irish mammal fauna for the stoat is in the absence of potentially competing small carnivores. In Britain there are two similar small carnivores, the stoat Mustela erminea L. and weasel Mustela nivalis L., which exist in the same habitats with similar diets (Day 1963). The stoat is bigger than the weasel and this difference in their sizes has long been regarded as resulting from natural selection due to competition (e.g. Huxley 1942; Lack 1947; Hutchinson 1959). In Ireland as mentioned earlier only the stoat occurrs.

The absence of weasels from Ireland is unexpected when viewed in the overall context of the weasel's European distribution. King and Moors (1979) showed that whereas stoats exist on islands of only 60 km^2, weasels do not occur on islands of less than 380 km^2. However, Ireland is clearly quite large enough theoretically to support weasels. King & Moors (1979) speculated that there once were weasels in Ireland but that they became extinct along with the lemmings. However there is, as yet, no supporting sub-fossil evidence. The absence of weasels from Ireland in the postglacial is

no mystery according to Yalden (1982) who has pointed to the absence of voles [until recently] the weasels principal prey.

G.E.Hutchinson in his celebrated paper 'Homage to Santa Rosalia' (1959) discussed the effects of sympatry and allopatry on animal species which had similar habits. One of the examples he used to demonstrate morphological character displacement was that of European stoats and weasels. For his allopatric examples he used subspecies of weasels from the Mediterranean coasts, where stoats are absent (see 1.3) and the Irish stoat. The skull lengths from Britain (sympatric populations) showed evidence of large stoats and small weasels. The allopatric Mediterranean subspecies of weasel had skull lengths which were greater than those of the British weasel. Available data on the skull lengths of the allopatric Irish stoat showed them to be smaller than their British equivalents (Table 1). The allopatric forms were considered to be examples of what is called competitive release and the differences between species in sympatry were considered to represent character displacement (Hutchinson 1959).

The Irish stoats were however a biased sample (see above) and the British stoats are now known to be more variable then the sample indicated (see 4.1.1). However the fact remains that the mustelids are certainly different in size as shown by their skull lengths.

Hutchinson proposed a 1:1.3 ratio for a minimum size difference in trophic structures to allow coexistence between ecologically similar species using the above and other examples. Since 1959 this explanation, based on competitive displacement, has been used to explain similar size differences in numerous animals, although many of these examples have been criticised (e.g. Grant 1972; Simberloff & Boecklen 1981; Ralls & Harvey 1985).

The phenomena of character displacement among sympatric species and character release in allopatric species became an important part of ecological theory (e.g Arnold 1981; Giller 1984). The example of European stoats and weasels has been quoted by many authors. The fact that Mediterranean weasels are very large and tend to be stoat-sized in the absence of stoats, and that weasels and stoats are most different in size when they overlap, is stated by Corbet (1966) to be "... an excellent example of character displacement". Williamson (1972) states that, using skull measurments of British stoats and weasels and Irish stoat, "It is certainly reasonable to suppose that the size difference in skulls results from natural selection caused by competition". Pontin (1982) states that the idea of character displacement in European Mustela is "... deceptively simple" although the Irish stoat " ... is clearly intermediate in size ". He also adds that such morphological differences may be the results of the "... climatically and

faunistically different areas from which the examples come which may well need different adaptation ". Character displacement has also been used to explain size variation in North American weasels and stoats (McNab 1971), however a more recent study has shown this interpretation to be incorrect (Ralls and Harvey 1985). To date, while several authors (Corbet 1966; Williamson 1972; Fairley 1975, 1981, 1984; King & Moors 1979; Ellenbrock 1980; Pontin 1982) have made comments on the question of character displacement/ competitive release in European weasels and stoats, there has been no systematic investigation of the subject. The Irish stoat, as an intermediate form between the British stoat and weasel, is an important component of the European example of character displacement in small mustelids. Therefore there existed a need for a reassessment of the ecology of the Irish stoat with new data.

It is clear that the Irish stoat is of scientific interest because it occurs on an island without weasels (and indeed many other mammals). However to ascertain how and why it is different, a more representative sample of Irish stoats is needed. It is this that the present study set out to obtain. Before defining the detailed study aims however, the distribution of stoats and influence of islands in general and Ireland in particular on their mammal populations will be reviewed (1.2 & 1.3).

1.3 DISTRIBUTION OF THE STOAT

Mustelids are the most common and widely distributed mammalian carnivores. The stoat is one of the commonest and most widely distributed mustelids. It has a circumboreal distribution throughout the Holarctic and it is found throughout the Palaearctic from the Arctic coasts south to the Pyrenees, Alps, Kashmir and Japan (King 1977b, 1983a). In the Nearctic it is found from the Arctic south to California and along the Rockies to New Mexico. It is absent from much of the North American central plains, but comes as far south as Iowa and Pennsylvania on the East coast (Burt 1952; Banfield 1974; Svendsen 1982). Stoats have also been successfully introduced to New Zealand from Britain (Gibb & Flux 1973).

In Europe the stoat is widespread, but it is not found on the Mediterranean coasts or Iceland (Brink 1967). It is found throughout Britain at all altitudes and on many off-shore islands (Corbet 1971; Arnold 1984). In Ireland it has been recorded throughout the mainland and from four off-shore islands (Crichton 1974; Ní Lamhna 1979). Little is known about the local distribution of stoats in Europe, but they are found in a wide variety of habitats, wherever sufficent cover is available (Corbet 1980). It is reported also that while weasels are common near human dwellings and in urban areas, stoats are rare in these habitats (Brink 1967; Alcock & Warsop 1982;

Dickman 1984). It is thought that the stoat originated in Europe, spread across the Palaearctic and crossed the Bering Bridge into the Nearctic (King 1983a). Its current distribution is thought to be influenced by several factors including the most recent glaciations (Macpherson 1965; Brown 1971), prey availability (McNab 1971; Simms 1979a),and its colonisation ability which in turn is influenced by its reproductive strategy (Simms 1979a; King 1984b). It has been proposed by Simms(op.cit.) that in some parts of North America at least, snow cover and interference interactions with other mustelids limit stoat distribution.

The stoat is often sympatric with other mustelids which could act as competitors. The most important of these are considered to be the similar-sized small Mustela species. These are : the weasel Mustela nivalis in the Palaearctic and New Zealand, and in the Nearctic the least weasel Mustela rixosa Bangs (considered to be conspecific with M.nivalis, both hereafter being referred to as weasels) and the longtail Mustela frenata Lichtenstein. The only substantial known areas of Europe where stoats and weasels are not sympatric are the Mediterranean coasts (weasels,no stoats) and Ireland and other smaller off-shore islands (stoats,no weasels). In the Nearctic the stoat is sympatric throughout the weasel's range. The weasel is however absent from some of the stoat's range, notably over some of arctic North America, most of western United States, coastal British

Columbia and the Maritime provinces of Canada (Banfield 1974; Svendsen 1982). Therefore there are two North American off-shore islands roughly comparable to Ireland in terms of size and mustelid distribution (stoats, no weasels). These are the island of Newfoundland (East Coast) and Vancouver Island (West Coast). The distribution of the longtail, an endemic North American mustelid, is more southern than that of its two relatives. It is sympatric with the stoat across much of the centre of the Nearctic region.

1.4 ISLAND MAMMALS WITH PARTICULAR REFERENCE TO IRELAND

Islands, because of their isolated animal populations, have played an important role in the development of biogeographical, evolutionary and ecological theories (MacArthur & Wilson 1967; Gorman 1979; Williamson 1981). The fact that islands have a reduced fauna compared to that of adjacent mainlands has attracted the attention of biologists from the earliest natural historians to present day ecologists.

These island mammals are often considerably different in size from their mainland conspecifics. Two examples are the large wood mice Apodemus sylvaticus (L.) found on off-shore islands around Britain and Ireland (Delany 1970; Fairley 1972a) and the extinct dwarf elephants Palaeoloxodon falconeri Busk of Mediterranean islands (Sondaar 1976). There are numerous other examples (e.g. Miller 1907; Brink 1967). The general trends are that on islands small mammals tend to get bigger and large mammals smaller. More specifically insular rodents tend to be bigger while insular lagomorphs, artiodactyls and carnivores tend to be smaller (Foster 1964), but there are some exceptions. This change in the size of animals on islands has been referred to as the 'island rule'.

The explanations proffered for this phenomenon are many, erratic, and plentiful. They include: relict status, character displacement, litter size, absence of predators, limited habitat availability, effects of limited or abundant diet and the genetic effects of restricted breeding population size (e.g. Corbet 1961; Berry 1964, 1969; Jewell 1966a; Foster 1964, 1965; Valen 1965, 1973; Sondaar 1976; Case 1978; Heaney 1978; Lawlor 1982; Lomolino 1985; Angerbjörn 1986). Currently, a widely accepted theory explaining its occurrence is that animals on islands, in the absence of ecologically similar species they undergo competitive release and hence expand the width of their ecological niche (i.e. have a wider diet and habiat ranges than their mainland relatives). The observed differences in size are considered as adaptations to this; the niche variation hypothesis (Valen 1965, 1973).

Ireland, which apart from the Isle of Man is the only area where the Irish stoat is found, is a continental island. It is smaller than the island of Britain (used here to mean England, Scotland and Wales) and extends less to the north and south (Fig.29). The Irish climate is notoriously wet and mild, snow rarely settles for more than a few days in winter (Orme 1970; Mitchell 1976). The number of species of birds, flowering plants, and mammals is lower than in Britain (Praeger 1950; Lack 1969; Fairley 1984) possibly due to the smaller land area and the consequent lack of some types of habitat

and the exclusion of certain species due to difficulties in postglacial colonisation (Sleeman, Devoy & Woodman 1986).

Ireland was directly affected by the glaciations of the last Ice Age. The penultimate glaciation is considered by many to have destroyed all forms of life. The ultimate glaciation was less severe, although it still probably turned most of the Irish landscape into arctic tundra. It is considered likely therefore that only arctic species, if any, could have survived. In terms of the present day Irish terrestrial mammalian fauna these species would include: stoat, Irish hare Lepus timidus hibernicus (Bell), pygmy shrew, red squirrel and pine marten Martes martes L.; all species that are found in the far north today.

The postglacial colonization of Britain and in particular Ireland by terrestrial mammals has long been the subject of speculation and controversy (e.g. Beirne 1947; Corbet 1961, 1962; Yalden 1982). The facts about Ireland's colonization by mammals are: (a) colonisation did take place, and (b) the mammal fauna is impoverished. The conclusion of most workers is that, however Ireland was colonised, the colonisation process was difficult and thus excluded some species which colonised Britain (Sleeman et al. 1986). Previous Irish mammal faunas, such as the last interglacial fauna, are also known to have been impoverished (Stuart 1986), presumably as the result of similarly difficult colonisations.

The existence of two different stoats on Britain and Ireland (referred to here as British and Irish stoats) has been used by Beirne (1947) to speculate that these represent populations isolated in areas of both islands during a glacial phase. In this context it is surprising that the Irish stoat, and not the British occurs on the Isle of Man, because of that island's proximity to mainland Britain, and the relatively shallow sea between the two. This was explained by Beirne as the result of the earlier postglacial spread of the Irish stoat, which he regarded as an relict form, to Britain and the Isle of Man followed by its extermination by the British stoat on the British mainland.

There are only three currently accepted endemic subspecies of Irish mammal, namely the Irish stoat, hare and otter Lutra lutra roensis Ogilby (Dadd 1970; Fairley 1984). This might be due to the impoverishment of Ireland's vertebrate fauna, and its relative youth as a distinct unit. Similarly there are only three accepted subspecies of Irish birds (Witherby,Jourdain, Ticehurst and Tucker 1945; Kennedy, Ruttledge & Scoope 1954). The descriptions of these endemic forms by splitters (1.1) were published in the period 1837 to 1947 (Appendix 1).

There is now little interest in describing endemic mammals. However there is an interest in the ecology of such mammals. Studies of

island animals are now often justified as studies of competitive release and resultant niche shift (Diamond 1970a & b ; Williamson 1981). Irish mammals provide examples of competitive release with resultant reverse in niche shift [change in niche width in presence of competitor see Giller 1984] . In some cases this has been reported as utilisation of a wider habitat range e.g. Irish hare, wood mouse, red squirrel and possibly pine marten, and in others wider diet e.g. Irish hare and pygmy shrew (Corbet 1966; Walker & Fairley 1968; Fairley 1972a, 1975, 1984; Grainger & Fairley 1978). There has also been some speculation that due to the absence of competitors, certain Irish mammals are present at higher population densities than elsewhere, showing 'density compensation' in the absence of competitors (e.g. Moffat 1938; Corke,Cowlin & Page 1969; Grainger & Fairley 1978). This phenomenon is a form of competitive release which is elusive and difficult to demonstrate (Williamson 1981) and there is, as yet, no evidence for it among Irish mammals. The more frequent occurrence of certain prey species in Irish carnivore diets could be due to higher densities of these species here, but could also be due to the absence of other prey species. Either way this implies ecological changes in the carnivores themselves.

1.5 AIMS OF THE STUDY

Scientific field studies of stoats have usually been prompted by economic, sporting, conservation or scientific interests. In northern Europe and North America, where stoats in white winter coats (called ermine) are an important fur crop, considerable research has been carried out (King 1975c, 1980d; Banfield 1974) due to economic interest. In Britain where gamebird protection is considered to be important, the role of stoats as predators has received much attention (e.g. Blank 1975; Potts & Vickerman 1974; Potts 1980; Tapper 1976; Tapper,Green & Rands 1982). In New Zealand, where introduced stoats have been blamed for declines in endangered native birds, research work has been prompted by interest in conservation (King & Moody 1982a-e; King 1984a; Moors 1983; Taylor & Tilly 1984). Elsewhere studies of stoats have mainly been prompted by scientific interest, either by splitters seeking new forms at the around the turn of the century (e.g.Bangs 1899; 1913; Barrett-Hamilton 1904), or more recent ecological investigations (e.g. McNab 1971; Erlinge 1977a,b & c, 1980, 1983; Simms 1979a&b; Ralls & Harvey 1985).

This study has been prompted by interest in the Irish stoat as an endemic subspecies. The aim of the investigation was to establish how different the Irish stoat is from other Mustela erminea. In

particular what justification there is for using the animal as an example of competitive release in view of the suggested character displacement in British stoats and weasels.

The Irish stoat is also a protected species under the Wildlife Act (1976) in the Republic of Ireland. It was one of the species protected under regulations (Protection of Wild Animals) in 1980 which enabled Ireland to comply with the provisions of the Berne Convention of European Wildlife and Natural Habitats. This was ratified by Ireland on 23 April 1982. The stoat has traditionally been killed here by game preservation interests (see 2.2.2; Ussher 1883; Flemyng 1913) and still remains unprotected in Northern Ireland and the Isle of Man. Its legal protection is controversial and thus it is hoped that additional information on stoat ecology, particularly diet, will lead to more a enlightened debate.

A complete investigation of an animal's ecology would be prohibitively detailed, therefore only selected aspects of the Irish stoat's ecology could be studied. These were: the animal's form, in particular the size and coat colour (3.1); use of habitat (3.2) and its food habits (3.3). There is also some background information on parasites (3.4); mortality and predators (4.3).

Section 2.

MATERIALS AND METHODS

2.1 LABORATORY STUDIES

2.1.1 Specimens examined

Previous workers on stoats and weasels have obtained most of their specimens from gamekeepers (e.g. Day 1968; Fairley 1971), this is no longer possible here as the stoat is protected in the Republic of Ireland (1.4). In this study licensed Fenn trapping was inefficient (3.2.1). Therefore an appeal was made for the carcases of stoats killed by road traffic or other accidents. The appeal was made via posters (approximately 1,000 circulated, see Appendix 2:D), talks and articles, during the period 1982-1985. In addition, a concurrent mammal road casualty survey was carried out over one year (Sleeman, Smiddy & Sweeney 1985; Appendix 2:E). In response to the appeal 183 stoats were collected. The hazards of the roads were assumed to be the same in all months, and the numbers of stoats killed per month were analysed using chi-squared tests (3.1.1).

All carcases were stored by freezing. All those examined were frozen for a minimum of 12 hours in an attempt to standardise any effect freezing might have on the animal's form. Every effort was made to discover the likely cause of death, locality, date and habitat(s) of each stoat carcase. The date and location provided

the necessary information as to wheather it was in a "vole area" or not at the time of capture, using the available data on the spread of the vole in Ireland (Smal & Fairley 1978; 1984; P.Smiddy- pers comm.; see Fig.17). Vole areas were defined as those within 10km grid squares from which bank voles had previously been recorded or areas totally surrounded by such squares. The habitats listed for road casualties were the habitats on both sides of the road. Some 15 stoats were made available that were killed and collected prior to the study (3.1.1). Data from all years were pooled, making the assumption that there were no substantial biological differences between years.

Collections of stoat specimens in various museums were also investigated (Table 2). Usually only preserved skins were available, and therefore only the ventral coat pattern was recorded. However, head-and-body measurements of two collections of British stoats, one from Scotland and one from England, in the British Museum (N.H.) were noted and used (see below).

In order to compare variation in British stoats and weasels and Irish stoats, data on head-and-body lengths were obtained (Fig. 28). The measurements for Irish stoats were obtained from this study (Table 6). Data on weasels came from published sources : a sample of 54 from England (Sussex) from King (1971 in King 1977c),

TABLE 2 MUSEUM STOAT SKINS EXAMINED

	MUSEUMS				
	National Museum [Dublin]	British Museum [London]	Ulster Museum [Belfast]	Royal Scottish Museum [Edinburgh]	Total
STOATS					
Irish	41	35	11	4	91
British	17	86	4	0	107
Totals	58	121	15	4	198

and a sample of 62 from Scotland (Aberdeenshire) from Moors (1974)(in King 1977c). As is usual, males were predominant in these samples. British stoat data were obtained from the collections in the British Museum (N.H.) and from S.C.Tapper of the Game Conservancy (Hampshire). The English sample of 15 stoats (13 males 2 females) came from four specimens obtained from Hampshire by the Game Conservancy, and from eleven specimens from Framlingham in Sufflok in the Gallwey and Hazlewood collection in the British Museum (N.H.). The Scottish sample of 16 stoats (12 males, 4 females) came from various areas in Perthshire from the collection of F.Nisbet in the British Museum (N.H.).

The Irish stoat carcases collected were dealt with using the following methods:

2.1.2 Form

The body measurements taken were: head-and-body length, tail, hind foot and ear lengths (to nearest millimetre). The methods used were the standard European techniques, as outlined by Corbet (1964). For head-and-body and tail measurements the animal was laid supine and the base of the tail was found by sliding a knife along the tail until it met with resistance from the pelvic girdle. This avoids use of the anus in measuring. The anus can change position with maturity, hence it is an unsuitable feature for measurement (Jewell & Fullager 1966).

Body weight was also recorded (to nearest gram). The stoats, because many were road casualties, were often damaged and desiccated leading to an underterminable weight loss. For this reason body weights were not used when comparing stoat sizes. Similarly, due to damage, the number of length measurements of the body varied considerably (Table 7); for example some stoats would have provided a tail length measurement and nothing more, others would have provided all except the tail measurement.

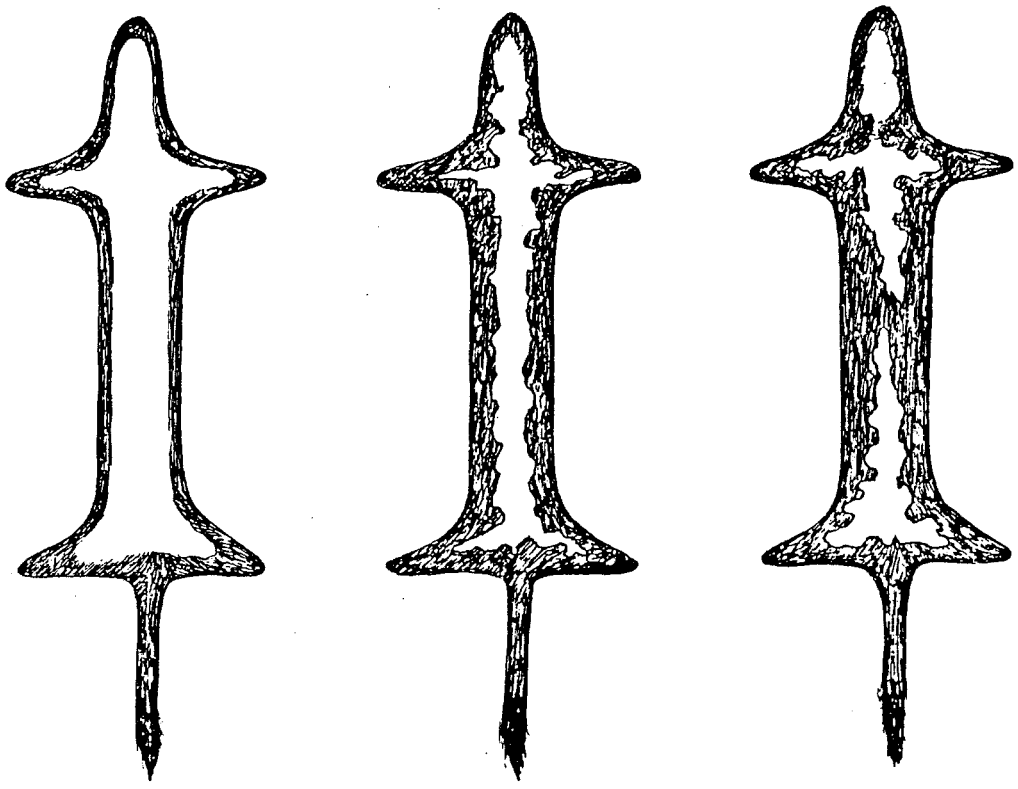


Figure 2. Ventral coat patterns of Irish stoats

(A): straight line between white and dark fur, usually with white upper lip, as in British stoat.

(B): irregular line between white and dark fur with uninterrupted white.

(C): irregular line and white interrupted usually at the neck.

The animal's outline was traced on paper and the ventral coat pattern added. If the animal was in suitable undamaged condition it was skinned. The skins were prepared as flat mounts on card in the manner recommended by Corbet (1964) and Nogorsen and Peterson (1980). All feet were retained on the skin.

Variation in the ventral coat pattern was divided into three categories: [A]: straight line between white and dark fur, usually with white upper lips as with British stoats, [B]: irregular line and uninterrupted white, and [C]: irregular line with white broken at one or more points, usually at the neck or belly (Figure 2 & 16).

Analysis of size difference between adults and young using mandible and head-and-body lengths was performed using t-tests. Because many stoat skulls were smashed the traditional measurement of stoat size, skull length (condylobasal length) was not used. Those skulls that were available had the standard measurements of length (condylobasal and mandible) and width (zygomatic) taken using the methods recommended by Corbet (1964).

Sexual size dimorphism was calculated as a percentage using the formula from Rossolimo and Pavlinov (1974):

$$D = \frac{\bar{x}\,\sigma^{\nearrow} - \bar{x}\,\varphi}{\bar{x}\,\sigma^{\nearrow}} \times 100$$

this was also used for similar work in New Zealand by King and Moody (1982c).

Data on geographic variation of the stoat within Ireland is available in the form of samples from each of the four Irish provinces (Fig. 17; Tables 9 & 10). Data on the north/south size cline is presented and analysed in a manner similar to that used by Fairley (1981). However, in this study only stoats that could be assigned to 10km grid squares were used. The distance of each stoat south from the 10 km line running immediately north of Malin Head (the most northerly point in Ireland) was measured. Regressions were done on mandible and head-and-body lengths by km south. This data was analysised using a one way analysis of variance and goodness of fit [how well x predicted y] was tested using an F test.

To determine if there was any difference in size between stoats from vole and non-vole areas it is important to eliminate the influence of any north/south cline on the data. Therefore only stoats from south of the 270km south (from Malin head) line were used. This is just south of Ballynalacken Castle,Co Clare, directly above the most northern vole area, referred to hereafter as the Ballynalacken line (Fig.17).

2.1.3 Reproduction and age determination

Reproductive condition was used to determine the approximate age of stoats. As young female stoats are reproductively mature (3.1.2) the convenient term "juvenile" cannot be applied, therefore as in King & Moody (1982c) the term "young" is used for both sexes here. In males the weight of the baculum (os penis) was used to distinguish adult from young males from April to December. Bacula of 30mg or under during these months were considered to be those of young animals (Plate 1A; Fig.9).

The bacula of males were removed and gently boiled. They were then defleshed by hand, defatted and bleached using the techniques recommended by Corbet and Southern (in Southern 1964). Bacula were dried to a constant weight. Apart from recording the weight of the bacula, the position and weight of the testes and the presence of sperm (detected by epididymal smear) were recorded for males. Female young were distuinguished from adults (assuming all adult females breed) for five months from April to august (Fig.11) on the basis of the presence of obvious nipples. In a sample of females the weights of the uteri and ovaries were recorded.

In addition, if available, skulls were used to age stoats using the extent of suture visiability and post-orbital ratios. Skulls were treated as discussed above for bacula. It is known that the narrowing of the post-orbital constriction (Plate 1B) is an indicator of age in stoats and weasels (King 1980c; King & Moody 1982d). Skull sutures were rarely clearly visiable but when they were it was on skulls from animals judged by reproductive status to be very young (Appendix 4). The post-orbital skull width to inter-orbital width (called post-orbital ratio) were successfully used in this study. However as road casualty stoats usually had crushed skulls these aging techniques were possible only on a small number of stoats. These techniques provided a check on those based on reproductive condition, and agreement was good in all cases (Appendix 4).

2.1.4 Food habits

The contents of stoats' guts were examined for prey remains. The guts (oesophagus to anus) were ligatured, dissected out and stored in 70% ethanol. Their contents were removed by a combination of squeezing, stripping and washing as described by Day (1968), Moors (1974) and others. The contents were then vigorously washed and sieved in a perforated dish (0.5mm perforations). Prey remains were then sorted under a binocular microscope. Small quantities of vegetable matter, including bits of wood, leaves, seeds and grass, were frequently found but were not included in the diet analysis. Similarly invertebrate remains were noted but not included in the diet analysis. As noted in similar studies (e.g. Tapper 1976) they form an insignificant portion of the contents and they are likely to have been ingested accidentally, as in the case of an ectoparasite Ixodes hexagonus which was found in a stoat gut during this study.

Identification of mammal and bird remains was based on hair and feathers. Reference collections of some hair of Irish mammals and bird feathers were made for comparison. Recovered hair and feathers (Plate 2A) were cleaned by rinsing in carbon tetrachloride [dry cleaning fluid]. Feathers were dry mounted on slides for

microscopic examination. They were identified using the key of Day (1966) in conjunction with the reference material. Many of the feathers recovered were ensheathed. It is considered likely that these were sometimes from fledgling birds, however they could not be distinguished from feathers of moulting birds. Other bird remains such as claws and beaks were found (Plate 2B; Appendix 8:A). While these were not used to identify birds here, their potential has been alluded to elsewhere (Walsh & Sleeman 1985). Small stones thought to be from bird gizzards were also found (Plate 2C). Mammal guard hairs were selected from mammal remains. Hair was examined by placing on a gelatin smeared slide for scale examination and then whole mounted in xylene for examination of size, shape and medulla structure. Day's (1966) key to hair was used with Irish reference material, along with illustrations in Brunner and Coman (1974) and Debrot, Mermod, Fiver and Weber (1982). The small number of possible mammal prey species in Ireland made it possible to identify hairs without cross-sectioning. This is also the case in New Zealand (King & Moody 1982b).

Previous workers have been unable to differentiate between hair of rabbits, Oryctolagus cuniculus (L.), and hares, Lepus spp (e.g. Day 1968; Fairley 1971). It is now evident however that there are differences, one of which is the scale pattern on their guard hair

shields. The scales of rabbit shield hairs have a continous wave pattern, those of hares are non-continuous or broken wave patterned (see illustrations: Brunner & Coman 1974 and Debrot et al. 1982).

This difference and cross-sections have been used in Sweden (Erlinge, Frylestram, Goransson, Högstedt, Liberg, Loman, Nilsson, Schantz & Sylvén 1984). However these Swedish investigators could distinguish between rabbits and hares in only 40% of their samples. No such difficulties were encountered here with reference material or actual samples. This may be due to the fact that whereas Erlinge et al.(1984) were dealing with the brown hare Lepus europaeus Pallas, in this study the hares were the Irish subspecies of the arctic hare, Lepus timidus hibernicus .

It is not known which of the two species of rat, the common rat Rattus norvegicus Berkenhout, or the ship rat Rattus rattus (L.), was detected, but in all except the small number of stoats from urban/suburban habitats it is probable that the rats were the former species. This is because the ship rat is now rare, occurring only [on the mainland] in urban areas of some ports (Ní Lamhna 1979) as it is in Britain (Taylor 1977).

Stoat hairs, quickly identifiable by the distinctive scale pattern and pale reddish colour were frequently found. In all but a single

incidence of suspected cannabalism (see 3.3.2) these hairs were considered to be the results of accidental ingestion. Small mammal bones and feet were found frequently, quantities of such bones being frequently associated with shrew hairs (Appendix 8:A).

If no identifiable vertebrate prey remains were found, the gut was considered empty. The frequency of occurrence of particular prey could therefore be calculated as a percentage of the total number of guts with food (Table 22). This method allows the role of a particular prey species or group of species to be expressed without reference to the rest of the diet. However it does assume that the probability of identification and the amount of time spent in the guts are the same for different prey types (King & Moody 1982b).

The calculation of the biomass contribution of each prey type to stoat diet was based on the work of Day (1963), King & Moody (1982b) and Gillingham (1984). Each prey type was assigned a weight based on Day's (1963) figure of a single stoat meal averaging 10g. Small prey: shrews, were given the weight of half a stoat meal: [5g]. Medium sized prey: woodmice, voles and birds, were given a weight of a single stoat meal: [10g]. Larger prey: rats and rabbits were given the weight of two stoat meals: [20g] assuming that stoats do return to such prey.[Caching of food is a typical behaviour of mustelids, widely reported for both

stoats and weasels e.g. Day 1963; Macdonald 1976; Simms 1979a; Moors 1983]. Relative contribution to prey biomass was calculated by loading the raw frequencies with these estimates (Table 22).

Differences between the diet of male and female stoats were tested (Table 23) using the Wilcoxon matched-pairs signed ranks test (Siegel 1956). Seasonal differences were tested using chi-squared tests (Table 24).

2.1.5 Parasites

The stoat carcases were initally brushed, using a tooth brush, over a white tray to dislodge ectoparasites. Brushing cannot be expected to remove all the lice; dissolving of the skin is necessary if this is to be achieved (Hopkins 1949). However, since all the stoats were examined by the same investigator it is considered that the lice collected were indicative of the populations present. The head, shoulders and groin area were searched for attached ticks. The white tray was then examined with a hand lens for the parasites. Mites were simply counted and discarded because some were unlikely to be ectoparasites, except on one occasion when the parasitic nature of the mites was clear due to the number present (3.4.2). Lice, ticks and fleas were retained in 70% ethanol. Lice and fleas were mounted and identified using the techniques of Hopkins (1949) and Smit (1957) respectively; ticks by using those of Arthur (1963) and Snow (1978). Differences between percentage lice infestation rates comparing the sexes and seasons were tested using chi-squared tests (Table 28).

Skulls were inspected with a hand lens to determine if damage by the nematode Skrjabingylus nasicola (Leukart) had occurred. Skulls were regarded as damaged using the criteria of Hansson (1968) i.e. if in the sinus area of the skull they showed, (1) obvious

asymmetry (2) perforations even in the absence of asymmetry, or, (3) appreciably thinned areas of the bone wall. Such damage cannot be used in directly assessing frequency of S.nasicola infections. However it was considered to be of interest as there are comparable data on rates of damage from elsewhere.

2.2 FIELD STUDIES

Trapping stoats and similar small carnivores is notoriously difficult (e.g. Day 1963; Moors 1974), and despite a considerable number of trap nights (1840) few stoats were caught in this study. Difficulty in trapping is likely to be due to the animal's comparative rareness in the environment and its preference for live prey. Because of this difficulty, all live stoats caught that were not near to giving birth, were immediately radio-tagged.

2.2.1 Fenn-trapping

Limited kill trapping was carried out licenced under the Wildlife Act (licence numbers: C(A)7/82; C(A)1/84; C(A)10/85) to provide specimens. The traps used were Fenn, Mark IV type, which are used for stoats elsewhere (Bateman 1971; King 1980a). They were set in tunnels made of locally available materials: stone, sugar beets, wood or clods of earth. Each trap was set with the spring parallel to the tunnel. The traps were inspected twice every 24 hours. Baits used were either rabbits guts, tinned fish-based cat food (kitekat, Pedigree Petfoods, Leics, U.K.) or stoat scent gland secretion from anal scent glands dissected from stoat carcases. Concurrent small mammal trapping was carried out at most Fenn-

trapping locations to find out if voles were present. The small mammal trapping was with snap or breakback mouse traps (Luna Brand), baited with raisins. Further small mammal trapping was performed outside the Fenn-trapped areas to ascertain vole distribution. Records of voles from this small mammal trapping were used to assist in the construction of the vole distribution map illustrated in Figure 17 and these are listed in Appendix 10:D.

2.2.2 Live-trapping study area

The live animal study took place over one year (1985) on Fota Estate, which was once an island in Cork Harbour. The estate is now joined to the mainland by three bridges and causeways. These connections ensure that the island's terrestrial mammal populations are not isolated (Fig.3). The Estate was privately owned until 1974, and was managed as a sporting estate with a resident gamekeeper until the 1950s. Traditional game-bird preservation techniques, including the planting of cover and vermin control (including stoat trapping) were practised when the estate was privately owned.

Fota, at the time of writing, is owned by University College, Cork. It is managed partly as a dairy and arable farm. The area of the

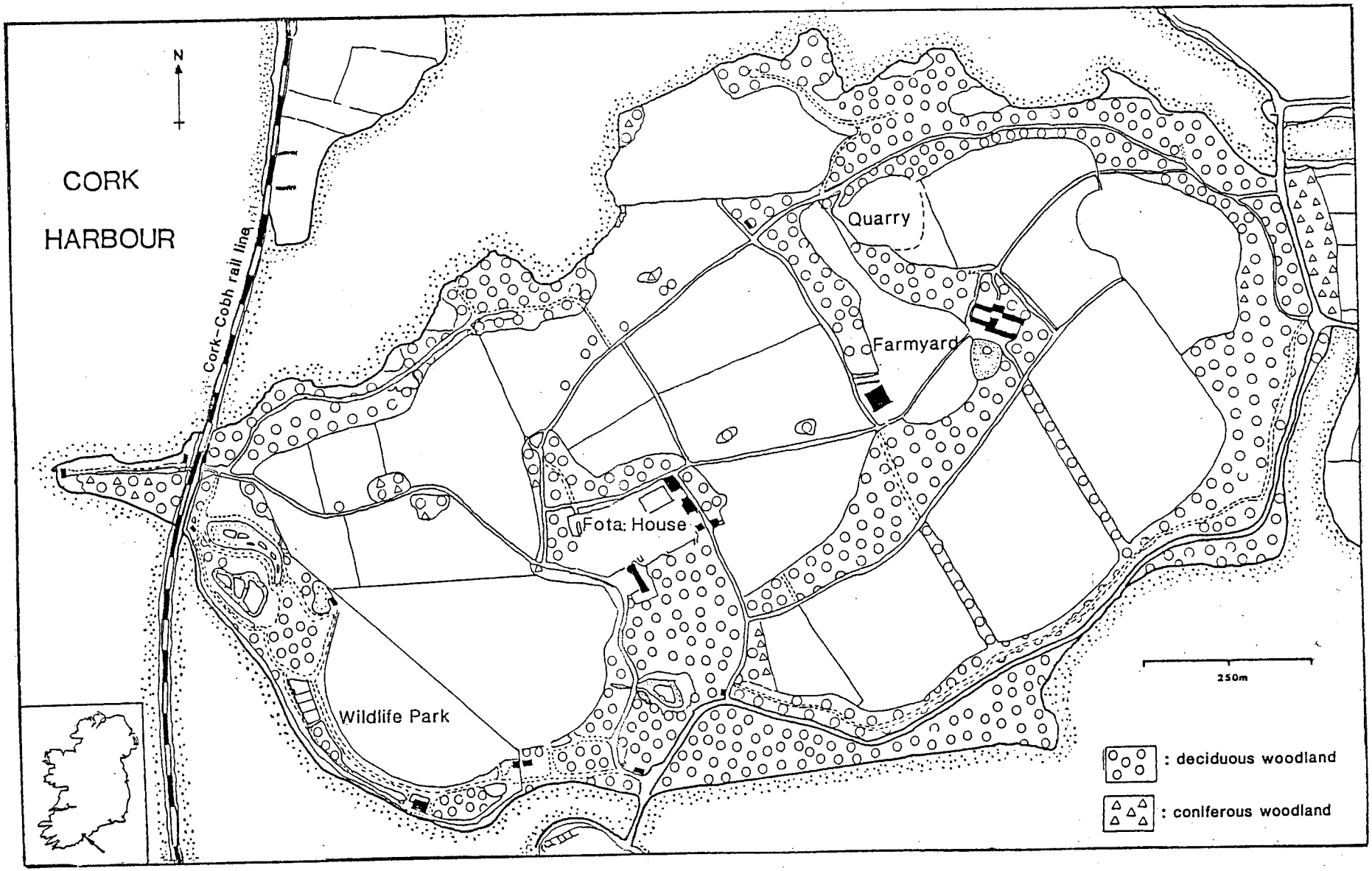


Figure 3. Live-trapping study area: Fota Estate, Co Cork

estate is 316 hectares (780 acres) of which approximately 100 hectares (247 acres) are woodland and 50 hectares (123 acres) are lakes, gardens, quarries or buildings (Fig.3). An area of 28 hectares (69 acres) is given over to a Wildlife Park, with a collection of exotic animals. The predominant geomorphological features of the estate are glacial till and gravels. There are some limestone outcrops and areas of estuarine alluvium (Kiely,Diamond & Feeney 1984). The woodlands are predominantly deciduous, the most frequent trees being : Oaks (Quercus robur L. and Quercus petraea (Mattuschka)), sycamore (Acer pseudoplatanus L.), elms (Ulmus spp.), beech (Fagus sylvatica L.) and lime (Tilia spp.). Conifers are uncommon (Fig.3) the most frequent conifer being the Scots pine Pinus sylvestris L. The understorey and scrub consists mainly of bramble (Rubus spp.) bracken (Pteridium aquilinum (L.)), rhododendron (Rhododendron pouticum L.) and elder (Sambucus nigra L.). The epiphytes ivy (Hedera helix L.) and clematis (Clematis vitalba L.) are common. The landscape of the estate is typical of an Irish lowland estate with a large "manor house", other estate buildings, and ornamental grounds .

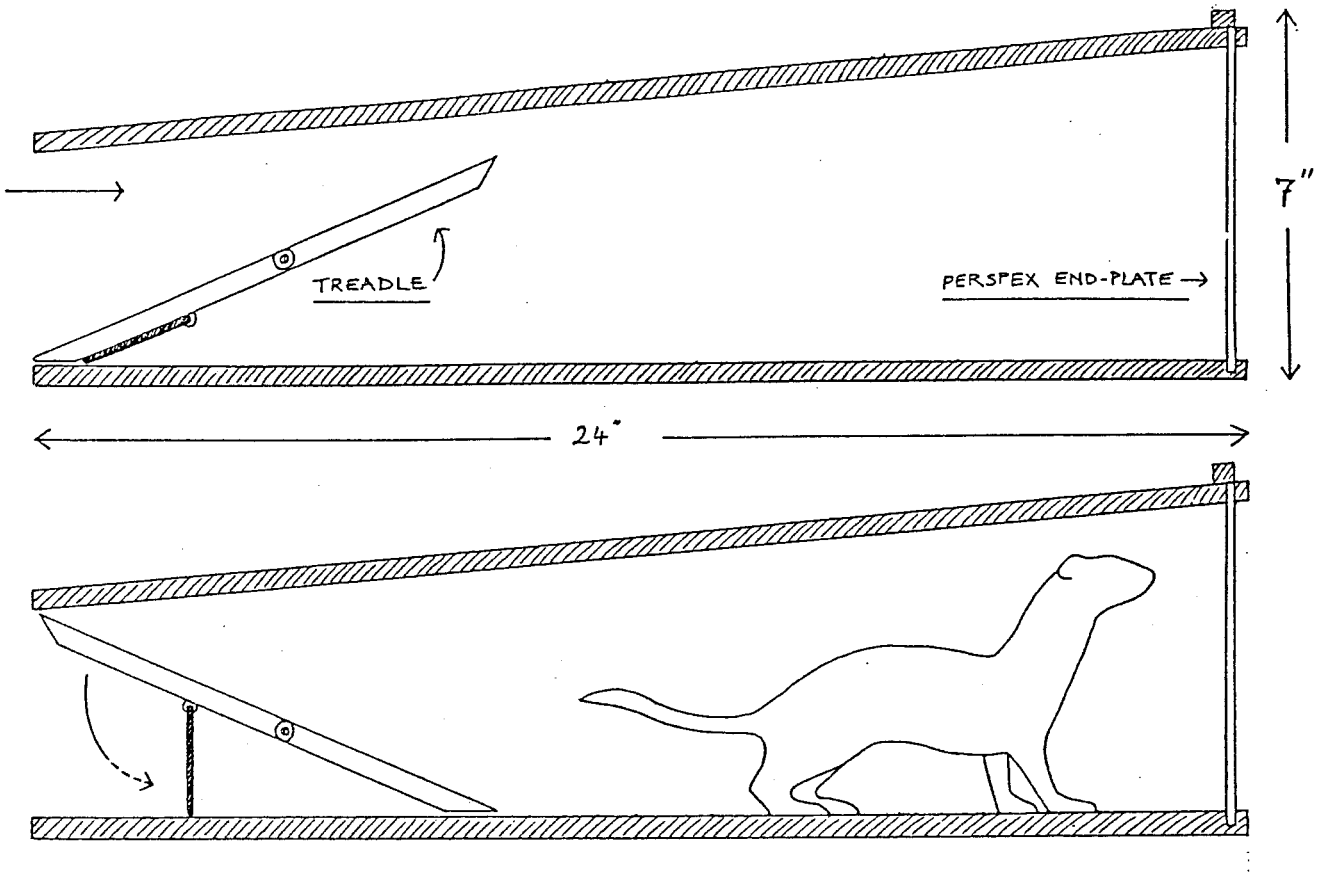
The wild bird and mammal fauna of the estate reflects the variety of local habitats. Woodland bird species such as the jay Garrulus glandarius (L.); sparrow hawk Accipiter nisus (L.); barn owl Tyto alba (Scopoli) and woodcock Scolopax rusticola L. are found in

the woods. The smaller avifauna of Fota has been described by Fleming (1980), while the island's foreshore is an important wading -bird habitat (Hutchinson and O'Halloran 1984). The estate's mammal fauna includes badger Meles meles (L.), fox Vulpes vulpes(L.), Irish hare, rabbit, red squirrel, common rat, wood mouse and shrew. There were no records of voles from the estate at the time of the study [1985]. The nearest location that the voles are known to have reached was less than 10 km to the north (P.Smiddy- pers.comm.).

2.2.3 Live traps and techniques.

The live traps used were designed specifically for this study (Fig.4), being based on the traditional tunnel trap relying on a treadle mechanism activated by the animal's weight as it moves through the tunnel (King 1973; Bateman 1971). They were constructed of exterior plywood, painted with one coat of linseed oil. They were made larger than the Whitlock trap which is used for weasels, and the similar sized traps used by Thompson and Fairley (1978). The larger area at the centre of the trap was provided as a sleeping area. Each trap had bedding and food supplied. The bedding was non-absorbent cotton wool. Unlike the Whitlock trap described by King (1973) they sloped in height from 7" (17.7cm) at the exit to 4.7" (11.9cm) at the entrance. A 9" (22.8cm) treadle with locking metal sprag closed the trap. The treadle was weighted with approximately 30g of lead at one end in an attempt to prevent mice from setting off the traps and to ensure smooth follow-through when stoats entered. In addition, elastic bands were connected to the sprag as a spring to ensure quick and efficient locking, as recommended by King (1973).

The traps were initally set in a grid, but as shown by the experience of other workers (e.g. King 1973) this pattern is too rigid to ensure concentrations of the traps in the most likely



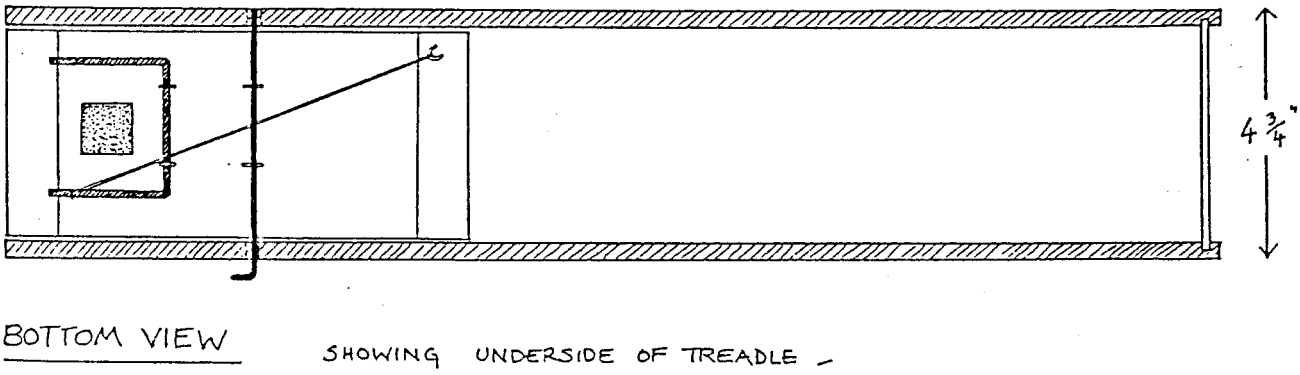


Figure 4. Live trap

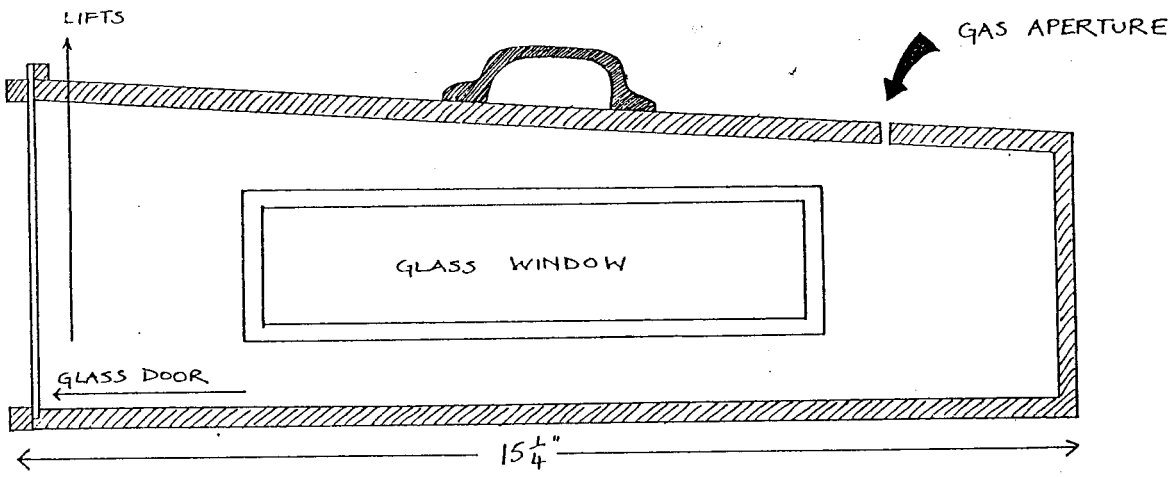
areas. Such likely areas were piles of stones or wood, under or beside logs and along hedges, paths and roads. The area covered by each trapping session varied considerably (Appendix 10:C). The traps were usually set in pairs, often with two different baits. They were inspected twice every 24 hours, and were re-baited every two days. Food baits were the same as those used for Fenn trapping (2.2.1). They were applied on stones and wood around the traps as well as in the trap. The scent gland secretions were however used sparingly and confined to the trap itself, being most vigorously applied to the treadle.

The products of scent glands have been used frequently elsewhere to lure animals into traps, for example to trap beaver (Castor canadensis (L.)) and several small carnivores (Bateman 1971). Stoat anal scent gland secretion has previously been used in trapping Irish stoats, but with little reported success (Thompson & Fairley 1978). The application of stoat anal scent gland secretion to live trapping offers an efficent method of catching dominant animals suitable for radio-tracking studies (3.2.1).

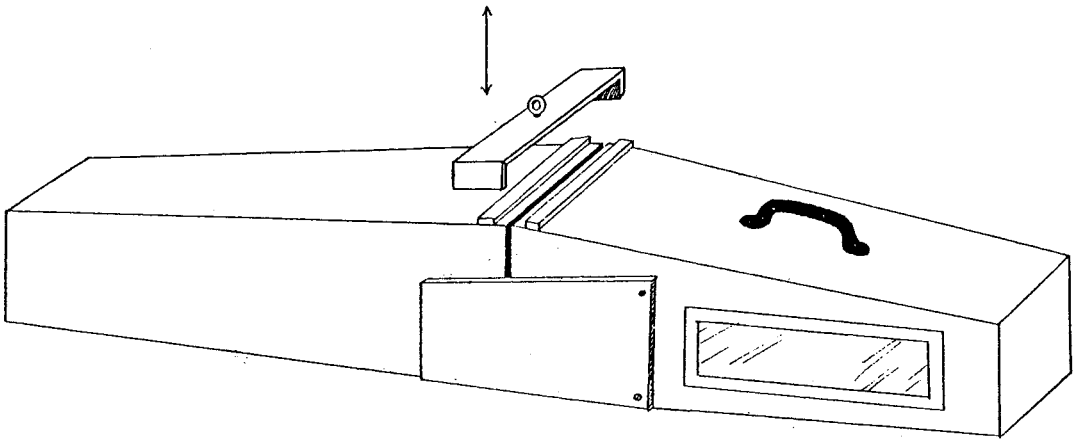
The food provided in the traps was cubed ox heart, or when available, dead white laboratory mice. The food was provided to prevent starvation. When activated, the trap was examined by torch through the perspex exit. It was quickly evident what species of

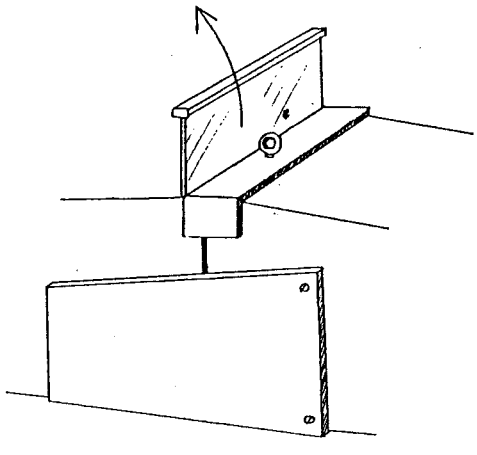
mammal had been captured, even if the animal itself was not visible. The species captured had very different characteristics. Stoats rolled the cotton wool into oblong sausage-like shapes and their scent was very evident, wood mice made small mice-sized holes in the wool and rats simply flattened the wool. The rodents, particularly rats, gnawed the wooden parts of the traps causing damage (Plate 3A) and often escaping. This damage was the biggest single cause of traps being non-usable. Passers-by sometimes interfered with the traps, or stole them, and on occasion the traps were flattened by farm machinery. These factors led to a continual decline in the numbers of traps used from 40 in January to 10 in December (Appendix 10:C). Surprisingly, wood mice and rats were caught in anal scent gland baited traps, but to a lesser extent than when the traps were baited with other lures. It is known that voles will avoid stoat scent, but the same is not true for wood mice (Gorman 1984).

Captured stoats were anaesthetised with ether in a specially designed box (a modified trap) with wooden brackets to attach it to the successful trap, a glass window and an ether entry hole (Fig. 5). Ether is widely used for anaesthesia of small carnivores (Lockie & Day 1964; King 1973; Simms 1979b; Chanin 1983). Captured stoats were dealt with in the field, using the methods recommended by King (1973; 1976), unless radio tags were being fitted. The



SIDE VIEW





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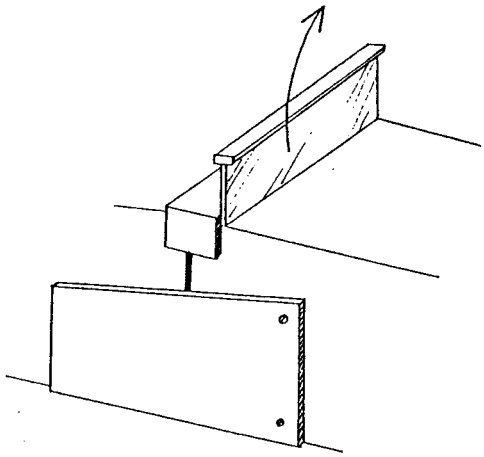

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Figure 5. Anaesthetising box

stoats were all weighed in cotton bags using a Salter Spring balance (British Trust for Ornithology, Tring, Herts.,U.K.). Radio transmitters were fitted to the stoats in the laboratory (2.2.4). All stoats were released at the point of capture. The bedding of a successful trap was removed, along with any scats. Bags and bedding were carefully searched for ectoparasites.

The age status of live trapped stoats was determined using signs of sexual maturity, namely obvious nipples in females. The single male trapped could not be identified as adult or young as it was trapped at a time of year (November) when the testes of both are not descended (Fig.8). The stoats were identified using the irregular ventral coat pattern (Figs. 2 & 16) which differed sufficently to distinguish between individuals. Irregular coat patterns have previously been used in field studies to identify individual weasels (Linn and Day 1966; King 1973; Moors 1974), mink (McCabe 1949; Chanin 1983) and otters (Jefferies, Wayre, Jessop, Mitchell-Jones & Medd 1984). In addition to the coat pattern, small numbered and coloured plastic tags (weight 0.18g; Rototag, Dalton Ltd., Nettlebed, Oxon., U.K.) were attached to the base of the ear. It was hoped that the use of different coloured tags would provide field sighting of individuals, however there were only two sighting of a non-radio tagged stoat, with such as tag. Both were by Wildlife Park staff. One was of the stoat in the process of eating some of the caged quaker parakeets (Myiopsitta monachus) in May.

2.2.4 Radio-tracking

Radio-tracking involves the use of miniature radio transmitters attached to animals to study their biology. It can be conveniently be divided into: radio-location; locating the animal in the field, and radio-assisted surveillance; using the transmitter to find the animal so that its behaviour can be observed (Kenward 1982). Both were used in this study, the former to monitor habitat and home range.

Four 'single-stage' transmitters (SR-1 type) were made specifically for stoats, in complete units, by Biotrack (Wareham, Dorset, U.K.). Two of the transmitters, designed for male stoats, were powered by lithium cells (450 mAh, 1.5V) and two designed for the smaller females were powered by lighter mercury cells (350 mAh 1.35V). Each transmitter used a slightly different frequency in the range 173.2-173.3 MHz. Each radio-tag (transmitter + cell) was equipped with two brass strips which formed an adjustable neck collar and acted as a loop antenna. The tag began to transmit when the two brass strips were joined. The transmitter, cell and proximal ends of the brass strips were embedded in epoxy resin (Plate 3B). The tags alone (without brass strip or resin) weighed 7.5g, while the complete tag unit weighed from 10-11.5g [4-5% of the stoat's body

weight]. Erlinge (1980) found that stoats quickly adjusted to tags of such weight.

All fitting of radio tags was done in the laboratory, because it required soldering and adjustment of the tag on anaesthetized animals. The brass strips were adjusted around the stoat's neck and soldered on the fold, a piece of card being used to protect the stoat's head and neck from heat and solder. After fitting, the transmitter was retuned by adjusting a variable capacitor, to ensure that it was giving the strongest possible signal. The capacitor was then sealed using a rapid-drying adhesive. The total time taken to anaesthetise, measure, fit the tag and return the stoat at the point of capture varied, but was always under 90 minutes.

The transmitters were tracked with a portable receiver (Mariner 57, Mariner Radar Ltd., Lowestoft, Suffolk, U.K.) ear phones, and a directional aerial (3 element Yagi, Mariner Radar). A dictaphone was used for note taking . The radio tags emitted 40-80 pulsed signals (heard as bleeps from the receiver) per minute. The signal was picked up, and by taking cross bearing from several points, using the signal's direction and strength (involving manipulating the aerial) the stoat's location could be ascertined. Finding a tagged animal in this way is referred to as taking a 'fix'.

The range of the transmitters was from approximately 100m at ground level in woodland to 300m in open areas, or when the stoat was up a tree. The home ranges of the stoats were often larger than the range of the transmitter and therefore the radio-tracking required much searching. High points such as hills, gate posts, and log piles were used to obtain better signals. One to three fixes, and occasionaly more, were taken per day. The character of the signal enabled some measure of activity to be recorded; constant signal indicating periods of rest and continual changes in volume indicating activity, as found by Erlinge (1980).

Every effort was made not to interfere with the stoat's normal behaviour, and tracking sessions or obtaining fixes rarely lasted more than 15 minutes. The animals tracked showed no aversion to the presence of man on occasions when visitors, campers and estate workers were in the area. Occasionally a tagged stoat could not be located for a day, or rarely even longer. This was probably due to the stoat entering relatively deep tunnels, which is known to prevent transmissions being received. Only two of the tags were finally recovered (both from female stoats). They were shed underground, one in a wood mouse hole and one in a rat hole. In the remaining two cases the tags were not recovered despite efforts to retrap the stoats in their (by then) known home range.

2.3 HABITAT UTILISATION

2.3.1 Habitats

The use of habitats by stoats was determined from a variety of data. For general habitat, data came from the Fenn-trapping, sightings and road casualty records of this study. In addition the stoat distribution records held by the Irish Biological Records Centre (IBRC)(generously made available by An Foras Forbartha) provided further overall habitat records. Some of these records, collected as they were by the public, came with little or no habitat information. Some confusion has been reported between stoats and squirrels in the IBRC records (Ni Lamhna 1979), and* therefore the present author checked each record used in this study. Data on general habitat use were also available from radio-location work.

The nature of the general habitat data available meant that only four simplified habitat catagories could be considered: wooded country, open country, seashore, and urban/suburban. Wooded country included all types of forests, shelter belts and scrub. Open country included all open areas such as arable fields and pasture, bogs, marshes, parkland and recreational facilities such as playing fields and golf courses. Seashore included sand dunes, salt marsh,

sea dykes and cliffs. Finally, there were the urban/suburban habitats which included car parks and housing estates.

Information on the area [in hectares] of each habitat available to stoats on Fota (2.2.2) allowed the determination of preference or avoidance of given habitats. The percentage area of two habitat types available: woodland and open areas, was calculated and used to predict the expected number of radio-locations from each, assuming that stoats were distributed at random throughout the study area. This was compared to the observed number of radio-locations using a chi-squared tests (Table 16) following, in part, methods discussed in Neu, Byers and Peek (1974).

More detailed habitat information was available from the radio-location data. The habitats referred to here are termed 'minor habitats' as recommended by Cox, Healey & Moore (1973) to avoid confusion with the more clearly defined term 'microhabitats'. The minor habitat data recorded the precise location of the animal within the wood or field (e.g. down a hole or up a tree). When the stoat was located underground the original inhabitants of the tunnel or burrow were identified, if possible . This was done using "spoor" [track, marks and faeces] and type of burrow entrances (see Bang & Dahlstrom 1972; Corbet & Southern 1977; Corbet 1980). The nearest opening to the precise location of the transmitter was presumed to be that occupied.

The following criteria were used to define a den site. The stoat had to be located in precisely the same location, resting (signal regular) at least twice (12+ hours apart) over a 48 hour period. While this undoubtedly led to some temporary dens not being noted, it avoided including foraging areas, as stoats are known to hunt underground.

In June 1984 the use of double sided tape tubes for detection of habitat utilisation by stoats was tested. In these tubes, guard hair left on sticky tape by visiting mammals are used for identification. Such techniques involving the removal of hair from passing mammals have been successfully used in North America (Hartesveldt 1951; Baker 1980). In Australia, Suckling (1978) developed a baited PVC tube (3cm x 10cm) with double sided adhesive tape on the inside. Such tubes proved successful in catching hairs from small rare arboreal marsupials. This technique has also been used in Britain (Dickman 1984; G.B.Corbet- pers.comm.). The trial at Fota involved use of 45 such tubes at various points in a 0.8 ha [2 acre] area of woodland and pasture over two weeks. It was hoped that these would detect stoat habitat utilisation. However, although the tubes did detect other species (wood mice and red squirrels) the technique produced no records of stoats and was abandoned (Appendix 12:B).

2.3.2 Home Range and Movement

The definition and calculation of home range is a much discussed topic (e.g. Burt 1943; Hawley & Newby 1957; Lockie 1966; Reeve 1982). Burt's (1943) definition is used here: "home range is the area over which an animal normally travels in pursuit of its routine activities" as restated by Jewell (1966b). Because live -trapping of stoats is difficult (see 2.2) and trap-revealed home ranges can be inaccurate, in this study, home range measurement relied entirely on radio-locations (2.2.4.)

All animals radio-tracked turned out to be residents, therefore the problem of defining the home range of transient animals did not arise. This is considered to be due to the use of anal scent gland secretions as trap bait (3.2.1). The lifetime of a miniature radio transmitter on a stoat is limited, so therefore was the time over which the home range information was collected (Table 14).

The home range was calculated using the minimum area method (MAM) using a convex polygon around 25m x 25m cells as used by Reeve (1982). This has been used in previous comparable studies (i.e. King 1975a). In this study however, areas of Cork Harbour, which are under water, were excluded from the home range (Fig.20). The 25m x 25m cells were also used to study home range utilisation,

while the number of radio-locations per cell were tabulated and are presented in Figures 23 and 24. To ascertain if the home ranges measured were accurate the areas as calculated from an increasing number of radio-locations was plotted (Fig.21), as advised by Hill and Robertson (in press).

As in other non-continuous radio-tracking studies, e.g. that on mink by Birks and Linn (1982), movements detected could be divided into two types: (a) observed small-scale movements presumably associated with foraging, with the animal usually returning to a den, and: (b) more extensive movements (usually unobserved) represented and measured by straight lines on a map. Both types of movement are illustrated in Figures 25 and 26. All movements detected were combined to give a Daily Movement Distance; the distance an animal moves in a 24 hour period [(DMD) after Garland 1983]. Type (b) movements made up most of the DMDs, however it was considered important that suspected foraging behaviour, [type (a) movements], when detected should be included. Observations of small-scale movements provided information on periods of activity and opportunities for radio surveillance (2.2.4). The irregular radio tracking that was carried out during this study must have resulted in many small-scale movements being overlooked and there are breaks of a number of days in DMD data (Fig.26). Therefore such data must be regarded as approximate.

Section 3.

RESULTS

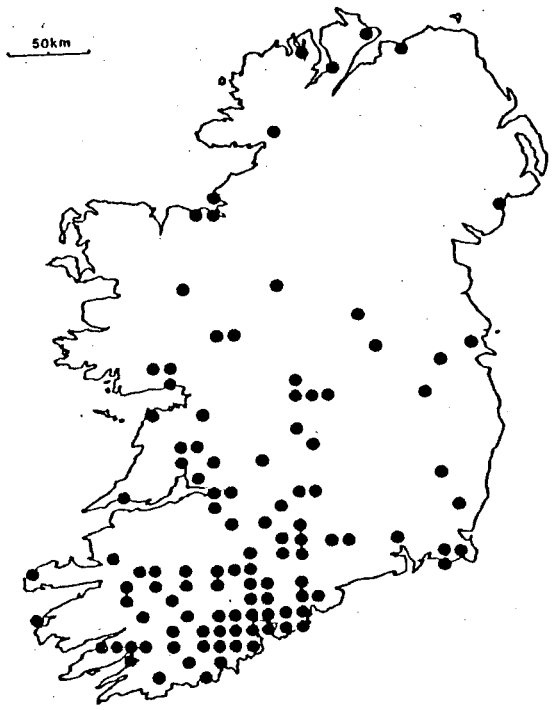
3.1 IRISH STOATS SAMPLED: THEIR FORM AND LIFE-CYCLE

3.1.1 The sample of Irish stoats

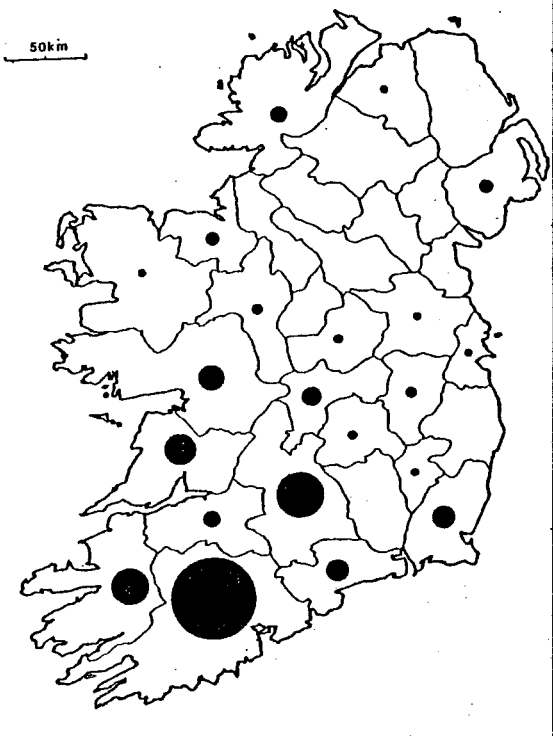
The specimens came from all over Ireland, but mainly from southern counties, particularly Cork (Fig.6). The sample was therefore regionally biased. Overall the most frequent known cause of death was traffic accident [82%](Table 3; Appendix 2:A). Most road casualties (89%) had broken skulls, and many (29%) had their abdominal contents removed by scavengers.

The road casualties [and Fenn trapped stoats] were predominantly male (Fig.7). The predominance of males is not considered to be a reflection of the natural sex ratio but rather due to a bias in the sampling techniques. The sex ratio of collections of stoats and weasels is usually dominated by males (e.g. Fog 1969; Fairley 1981; also see below) although it is known that the sex ratio is normally unity at birth for both stoats (Müller 1970) and for weasels (King 1975b). The reason for the predominance of males in the road casualty sample is not known. It may be that since males are bigger than females they were more easily detected. It has been suggested that this is due to the fact that they have bigger home ranges and hunt less often down tunnels (King 1983a). It is suggested here that seasonal enlargement of home range leads to

Figure 6. Areas where the stoats were obtained



A : Sites of collection (10km grid)



B : Representation of the numbers of stoats from each County

NUMBERS FROM EACH COUNTY WERE: ONE • FROM DUBLIN, MAYO, DERRY, CARLOW AND MEATH

TWO • ROSCOMMON, KILDARE, WESTMEATH AND LAOIS; THREE • DOWN AND SLIGO;

FOUR • DONEGAL, LIMERICK AND OFFALY; FIVE • WATERFORD

SIX • WEXFORD; SEVEN • GALWAY;

TEN • CLARE; 13 • KERRY;

26 • TIPPERARY. 96 • CORK.

TABLE 3 SOURCES OF IRISH STOATS STUDIED

	Causes of death			Totals
	Road Casualties	Trapped	Other	
Irish stoats from Ireland	162	15	19	196
Irish stoats from Isle of Man	2	0	1	3

TABLE 4. SEX AND AGE OF THE IRISH STOAT SAMPLE, BY MONTH
[excluding stoats from the Isle of Man]

Month	Age	% males	Number of Males	Number of Females
April	Young	50	1	1
	Adult	88	23	3
May	Young	100	2	0
	Adult	82	14	3
June	Young	67	8	4
	Adult	14	1	6
July	Young	75	12	4
	Adult	67	2	1
August	Young	60	6	4
	Adult	71	5	2
September	Young	33	0	8
	Adult		4	
October	Young	86	4	1
	Adult		2	
November	Young	53	5	7
	Adult		3	
December	Young	80	4	1
	Adult		0	
January	Age Unknown	100	2	0
February	Age Unknown	85	5	1
March	Age Unknown	85	17	3

Age, sex or month unknown: 27.

road casualties (see below) and therefore the fact that males usually have larger home ranges than females is the most likely cause of the high numbers of male casualties.

The road casualties appeared to be highly seasonal. There are pronounced seasonal peaks in collected stoat road casualties. For adult males there is a significant difference between the numbers of male stoats killed per month ($\chi^2 = 44.06$ $p < .001$); the main peak occurs in March, April and May (Fig.7a; Appendix 2:D). Similarly there is a significant difference between the numbers of females collected per month ($\chi^2 = 24.22$ $p < 0.02$), with a peak in June, most of which (6 of 8) were adults (Fig.7b; Appendix 2:D). Higher numbers were also collected in September and November but these were months when adults and young were not distinguished.

Young males appear in the sample before young females (Fig.7; Table 4) which possibly suggests that young males roam earlier than females. Equally it may simply be a reflection of the preponderance of males in the sample. Road casualty stoats must be regarded as a non-random sample of the population, being biased in favour of the reproductively active males in the spring and females and dispersing young during summer and autumn.

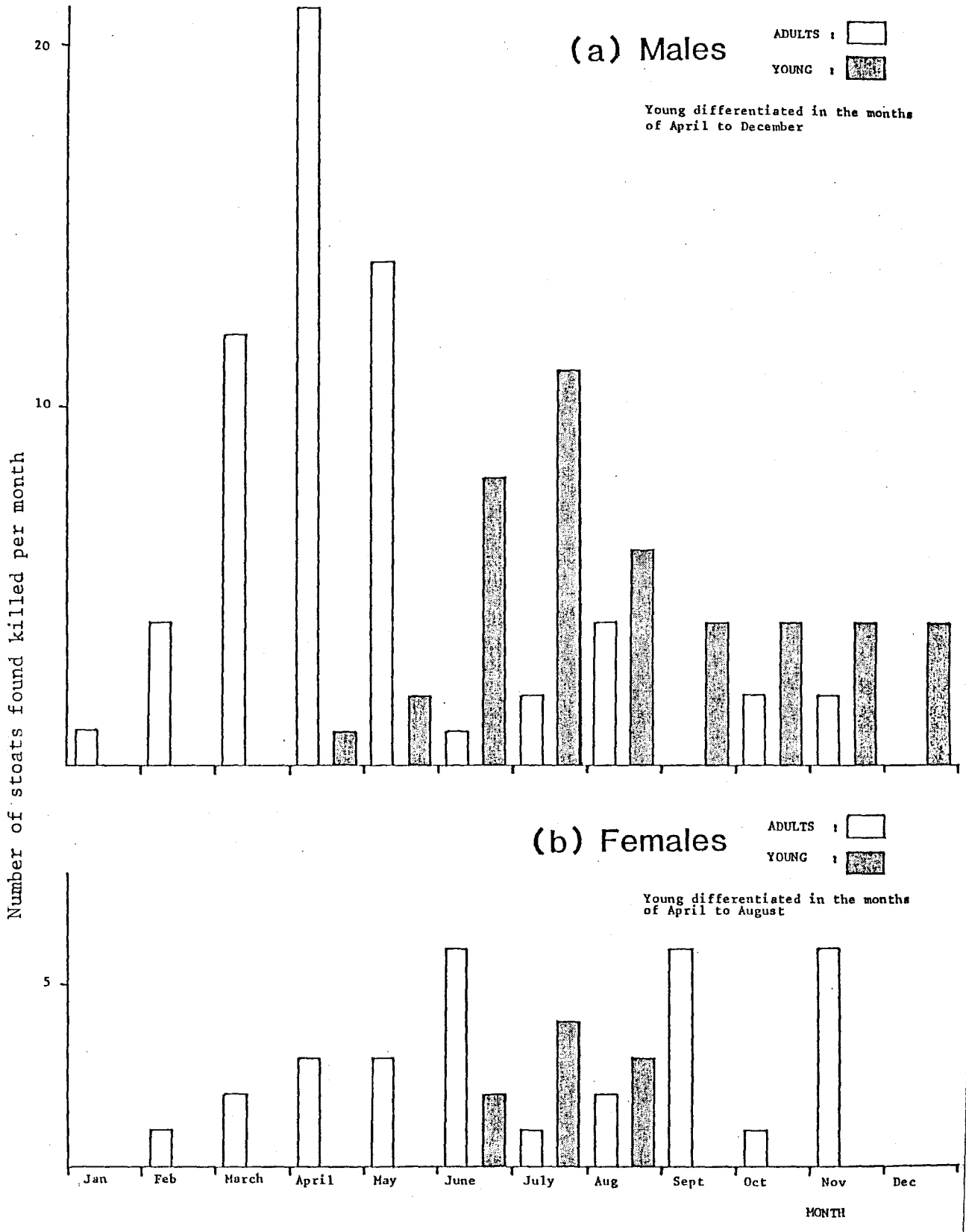


Figure 7 Road casualty stoats according to month killed

Fifteen stoats were trapped, this being 7% of the overall sample. Of these, eight (6 males; 2 females) were taken in Fenn traps. These were taken during 459 trap nights. These traps also caught rats and cats (Appendix 10:A). Four stoats were taken in Longworth traps. These were accidental casualties which surprised the two researchers (Drs C.M.Smal & W.I.Montgomery) who trapped them. In Britain weasels have been trapped in Longworths (Lightfoot & Wallis 1982), so it is of interest that stoats turned up in these traps here. Two stoats were taken illegally in gin traps and were passed on by the Wildlife Service, while one stoat was an accidental casualty in a marten livetrap. The sex ratio of trapped animals was biased in favour of males (10 males to 5 females). Three of the females were trapped in Longworth traps, which is what might be expected, given the small aperture (6cm x 5.3cm) of these traps. The one male caught in a Longworth trap was young and very small.

The final eighteen stoats from Ireland were in the 'other causes of death' category (Table 3) and were composed of the following: nine whose cause of death was unknown and which were found in freezers of various research establishments; six which were reported to have been taken from domestic dogs (Canis familiaris L.); one from a cat (Felis catus Schreber), and one recovered from an old gamekeeper's "gibbet" or vermin display line. Two of the stoats taken from dogs were seen being killed by the dogs, these and two

more had injuries consistent with being bitten and probably killed by the domestic carnivores. One stoat was found at an otter (Lutra lutra (L.)) feeding site (W.O'Sullivan-pers.comm.).

In order to ascertain if stoats from Ireland were in a vole or non-vole area, some small mammal trapping was done in suitable habitats (3.2.2) in order to supplement published information on vole distribution. At Fota, 206 snap trap nights in suitable habitat (Appendix 10:B) failed to detect any voles and caught only wood mice. Small mammal trapping in other areas resulted in the capture of voles, wood mice, a shrew and a house mouse, Mus domesticus (L.)(Appendix 10:B).

A small sample of Irish stoats from the Isle of Man was also collected during the study (Table 3; Appendix 2B) as were some British stoats and weasels (2.1.1). These will be referred to later in Section 4.

3.1.2 Reproductive Cycle

Reproduction was investigated using the methods outlined in 2.1.3. The results are presented as an account of the annual reproductive cycle of each sex.

Young males take a year to become sexually mature. Their testes were small and undescended until January, though some remained undescended in March. Sperm was not found in the epididymes until March. Most males had descended testes and sperm in their epididymes from March until June, and a few (adults) were found in one, or both conditions until September (Fig.8). From mid-August until January the testes of adult males are regressed, similar to those of young males. It is clear that some males are not fecund during the breeding season from mid-March to August (Fig.8).

The baculum weight (Fig.9) reflects a similar spring and summer pattern to that of testes weight, but because bones survive better than tissue more baculum weights were available. However, in autumn and winter, when testes of adults regress and become lighter (Fig.8) bacula continue to increase in weight (Fig.9).

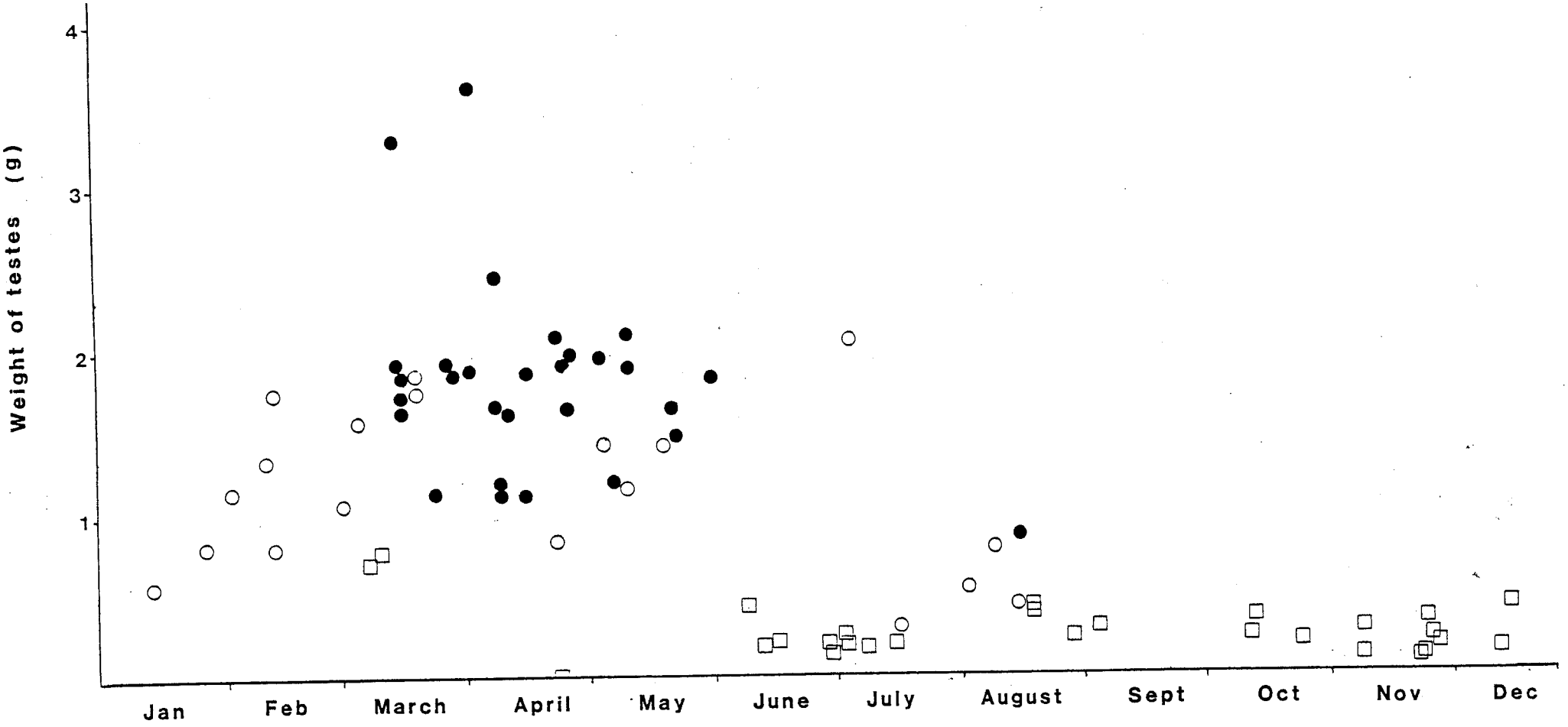


Figure 8. Testes weight of male stoats according to date killed

○: descended testes ●: descended testes with sperm □ :undescended testes

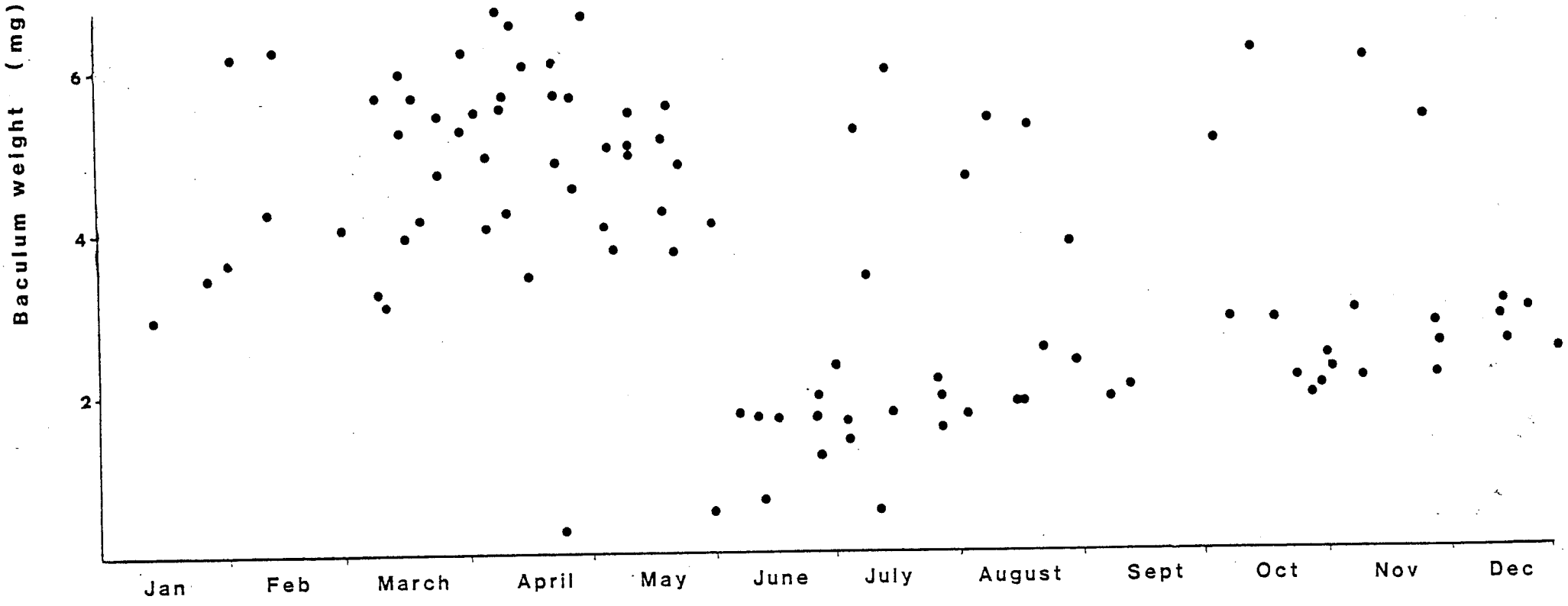


Figure 9. Baculum weight of male stoats according to date killed

There were fewer female than male stoats for study, particularly in the spring, which means that few pregnant or lactating stoats were available. A single pregnant stoat, Fenn trapped on 20 March, was examined. It had 12 embryos which had a mean individual weight of 2.6g and altogether weighed 31g (weighed after storage in formalin). This female had 12 obvious nipples, seven on the right side and five on the left. There were nine males and three females (sexed by G.I.Twigg).

This pregnant stoat would have shortly given birth in late March or early April. Similarly, a female stoat live-trapped at Fota on the 10 April weighed 210g, but when retrapped two days later weighed only 175g (Table 13). It is considered likely that this female gave birth between the 10 and 12 of April. This sparse evidence plus other observations in England (Deansley 1935, 1943), Scotland (East & Lockie 1965) and Ireland (Fairley 1971) indicate that stoats in these islands are usually born around early April.

The fact that lactating females were found in April, May, June and early July along with the single very high recorded weight of uterus and ovaries in early April (Fig.10) provides further evidence that early April is the time of birth. It was assumed that all adult females breed and would therefore have obvious nipples from April to August. Those that did not were considered to

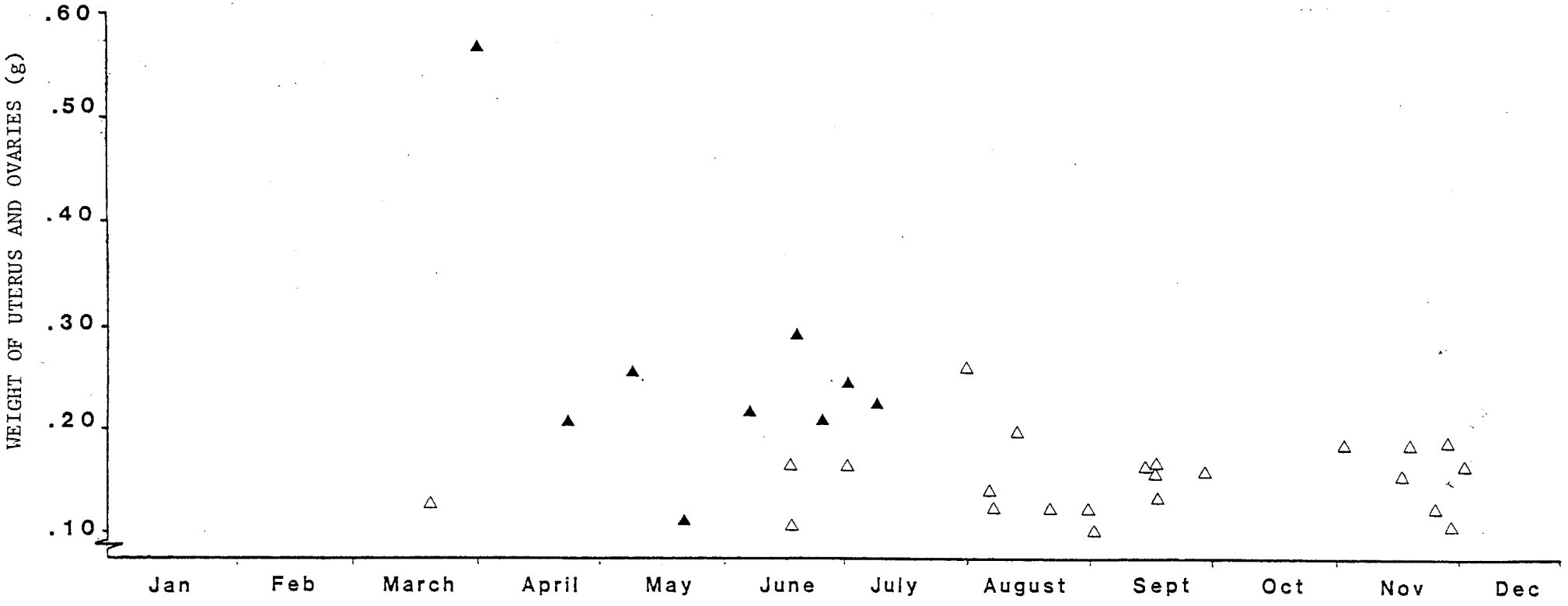


Figure 10. Weight of uterus plus ovaries for female stoats according to date killed

△: NON LACTATING ▲: LACTATING

be young (3.1.3; Fig.11). Uterus and ovary weights are derived from a limited sample of only 32 individuals. They show quite variable weights in the months from March to August (Fig.10). As has been found elsewhere (e.g.King & Moody 1982d), this is due to the mixed sample of reproductively active mature stoats and young at this time of year. In contrast, such weights are uniformly low from September onwards, indicating reproductive quiesence in adults as well as young.

A total of 21 stoats were found to have visible nipples, and this condition was recorded in every month except January, February, October and November. Equal numbers of females (five individuals in each case) had eight, nine, ten and twelve nipples while one individual had seven. The mean nipple number was 9.1 (SE= 0.072). Most had an equal number of nipples on the left and right, however eight (38%) had one or two more nipples on one side. The nipples varied considerably in size, and difficulty was experienced in distinguishing functional from non-functional nipples. This difficulty was also reported by King & Moody (1982d).

3.1.3. Growth

Stoats in Ireland are born around early April (3.1.2.). The size of the young at birth is not known, however we do know that embryos removed from a female killed on 20 March had a mean individual weight of 2.6g (3.1.2). A captive female Scottish stoat gave birth in captivity in April to 9 young, each weighing between 4-7.5g (East & Lockie 1965). It is assumed that Irish stoats have a similar weight at birth.

The young are therefore born by mid-April with an assumed weight at birth of up to 7.5g. They begin to appear in this study in the same month and they predominate in the samples of June, July and August (Table 5).

The increase in body weight of males is rapid, and by June they have gained most of their adult body weight, at circa 280g (Fig.11). Therefore over the approximately 90 days of April, May and June they gain up to approximately 273g. Growth in head-and-body length is also rapid. Young males reach adult length around September, but most growth has occurred by June (Fig.13).

The low adult male head-and-body length and weight in January (Figs.11, 12 & 13) results from the fact that the only two males

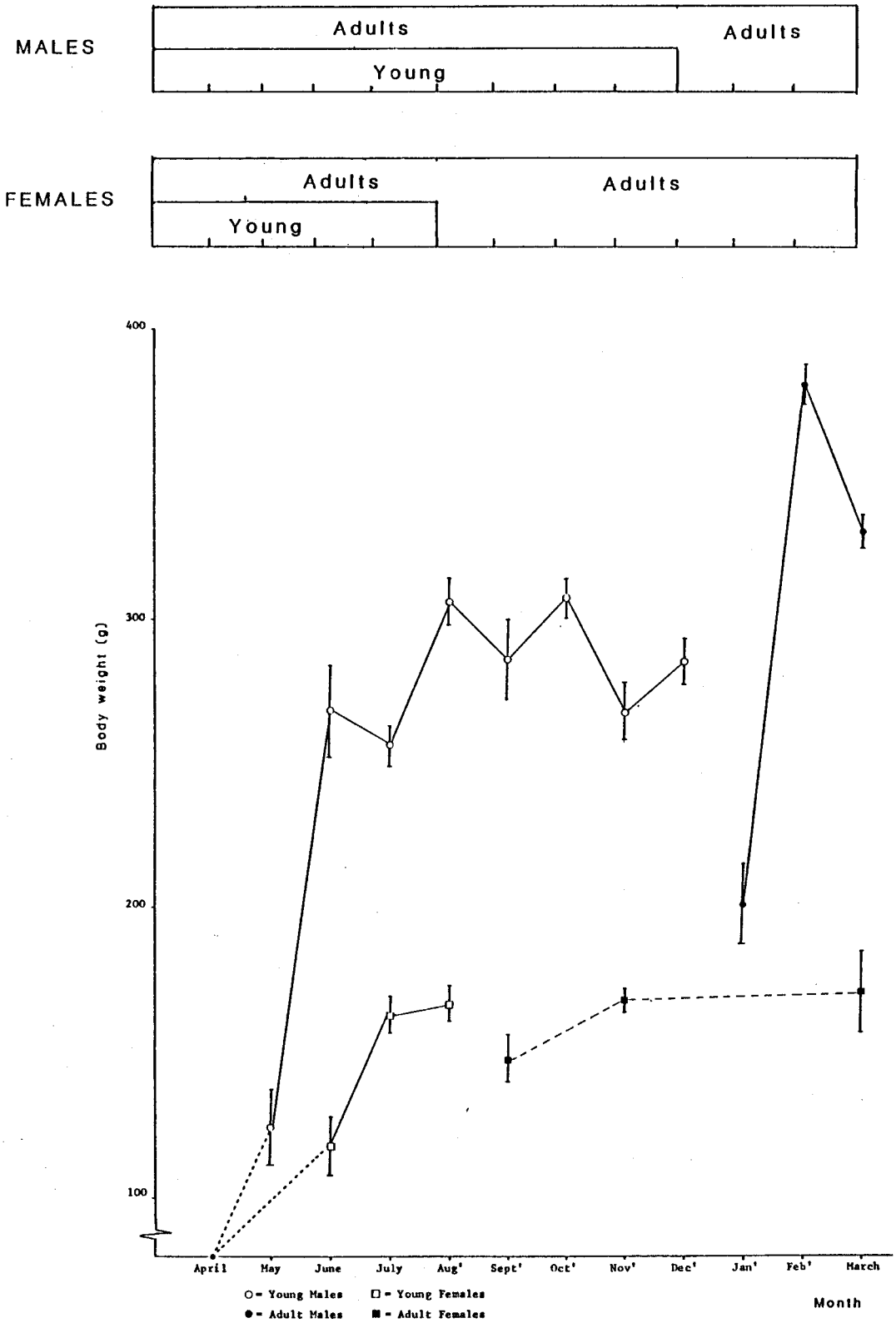


Figure 11. Age categories (above) and mean body weight of stoats by month (below) (±SE)

----- denotes month(s) when specimens were unavailable

available during that month were small males from Co Donegal (Ulster). Similarly, regional variation in stoat size makes young stoats appear larger than adults (e.g. Fig.13, July for females and October for males). Young females appear to reach adult weights and lengths (both head-and-body & tail) more rapidly than males (Figs. 11; 13 & 14). Growth in tail length (Fig.14) reflects similar trends in head-and-body length. Tails of young males grow rapidly and are adult length, or even longer by June. This apparent increase in tail length of young males beyond the mean of adults is consistent over 3 months (June,July and August) and it may indicate that there is some tail length loss in maturing male stoats. This could account for the high variation in male stoat tail length (3.1.4). Females tails are already adult lengths by June (Figure 14). The same growth trends are reflected in the lengths of ears and hind feet (Appendix 5:E).

Size [head-and-body and mandible length] of young male stoats was was not significantly different from adult males [$p < 0.05$] from August onwards (Table 5). Young females reached adult size even earlier. Those young females collected in July and August were not significantly different in size from adult females (Table 5). It is evident therefore that the most significant growth takes place from April to July, before the stoats leave maternal care. It is clear therefore that adult skeletal size is determined within this period, and that females reach adult size faster than males.

TABLE 5 SIZES OF ADULT AND YOUNG STOATS.

Young males collected from August onwards, young females in July and August.

	n	mean	t	at $p < 0.05$
HEAD-AND-BODY LENGTH				
MALE				
Adult	70	282.5	0.98	not significant
Young	18	278.3		
FEMALE				
Adult	36	238.1	0.49	" " "
Young	8	242.7		
MANDIBLE LENGTH				
MALE				
Adult	55	27.3	0.80	" " "
Young	18	26.9		
FEMALE				
Adult	31	23.0	0.39	" " " " "
Young	5	23.0		

Adult measurements from Table 7, young measurements in Appendix 5D

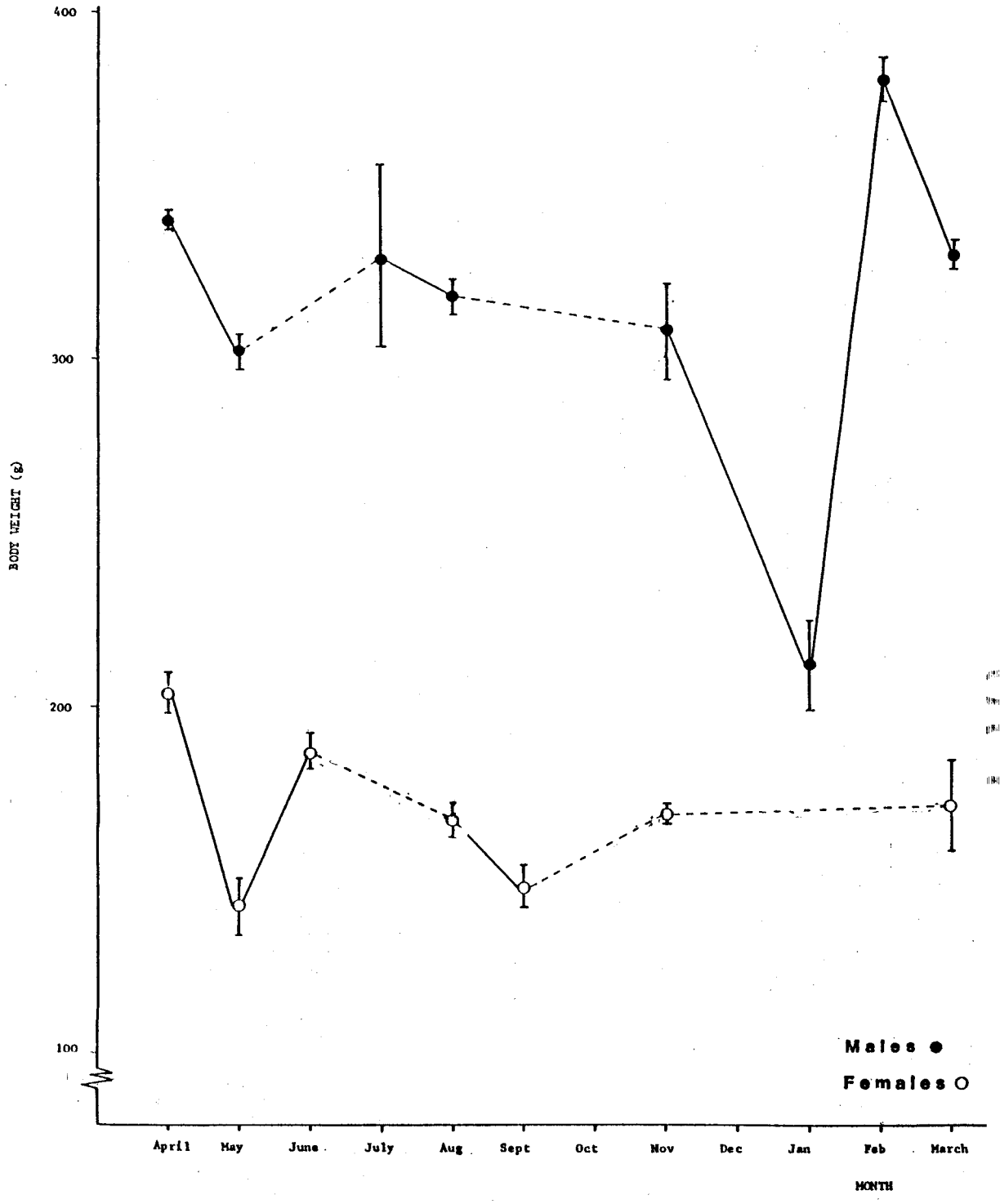


Figure12. Mean body weight of adult stoats (±SE)

----- denotes month(s) when specimens were unavailable

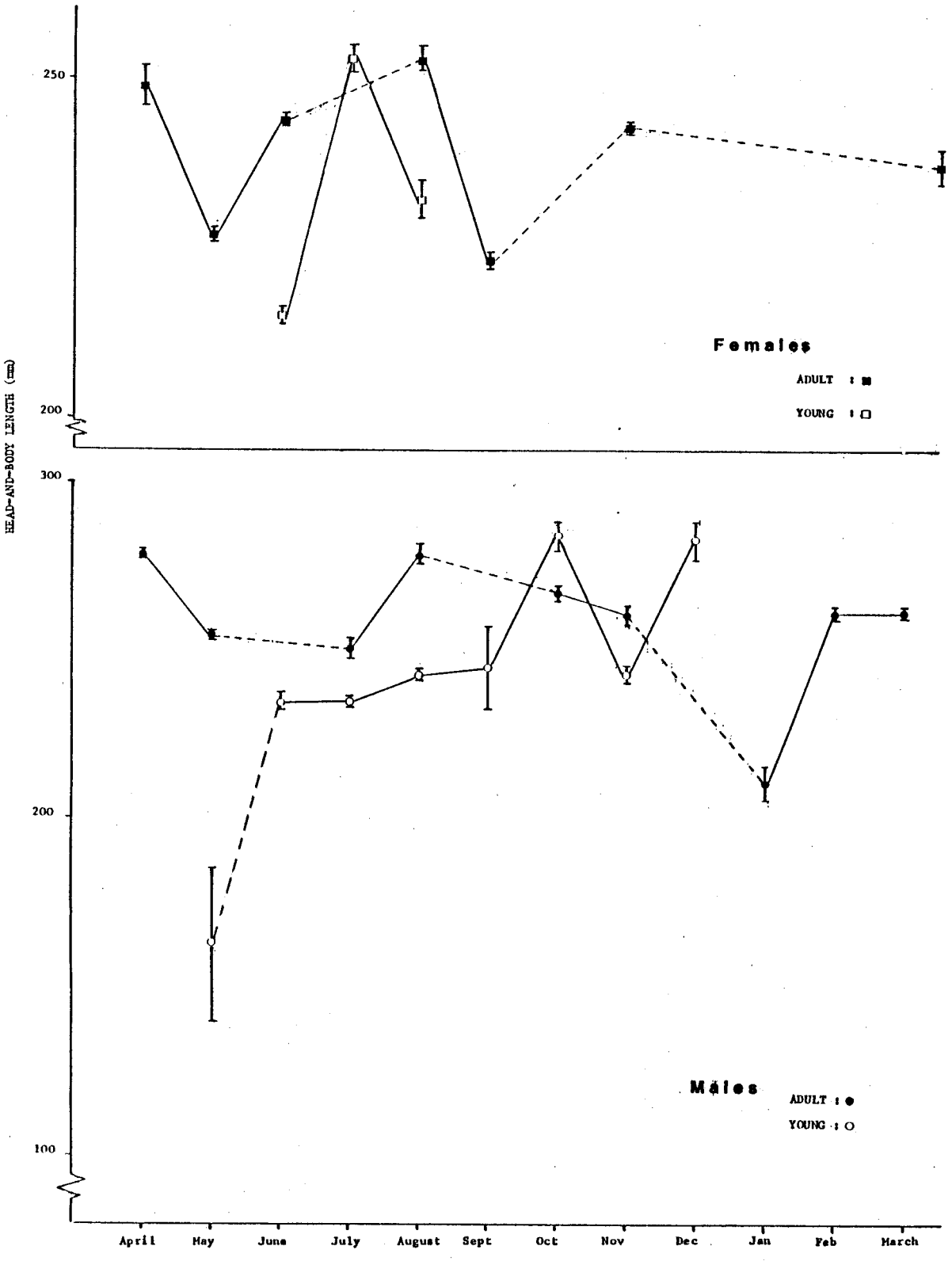


Figure 13. Mean head-and-body lengths of stoats (± SE)

----- denotes month(s) when specimens were unavailable

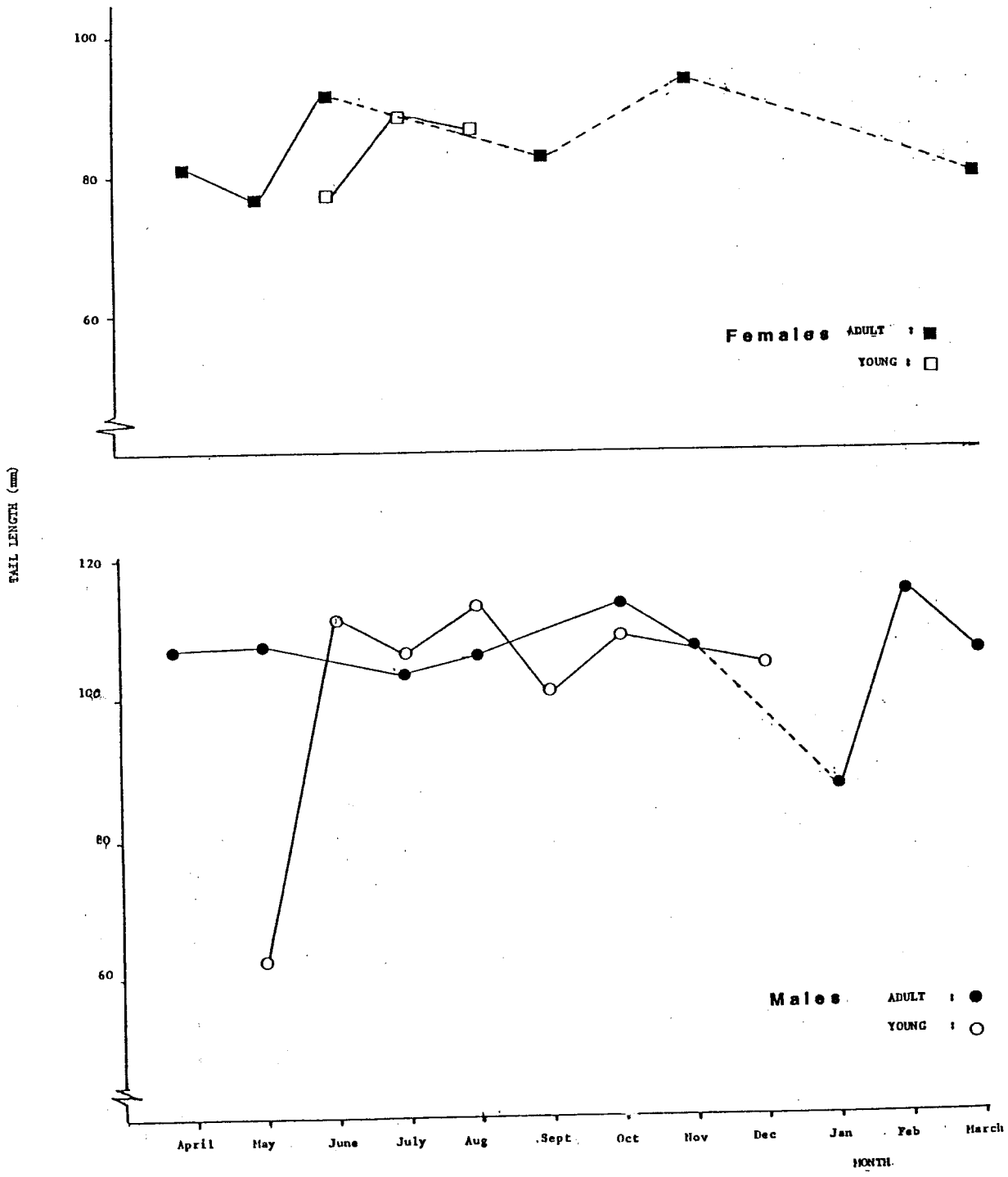


Figure 14. Mean tail lengths of stoats

----- denotes month(s) when specimens were unavailable

3.1.4 Form

The measurements of adult and young stoats are summarised below: body measurements in Table 6 and skull measurements in Table 7. Most of the young sampled were close to adult skeletal size despite being below average adult body weight (3.1.3).

Some groups of measurements are characterised by relatively high standard errors, indicating considerable variation. This is particularly true of body weights, length measurements of young, and somewhat surprisingly, tail measurements of adult males (Table 7). Body weight is a notoriously variable quantity. It is influenced by several factors other than geographic and age variation, e.g. the freshness of the carcase when frozen, its condition, reproductive state and the time of the stoat's final meal. Damage to stoat carcases from road accidents is thought to have contributed considerably to weight variation. Some of the variation in weight is also produced by geographical variation, for example the two small males from Co Donegal in January (3.1.3) and the small female stoats caught in Longworth traps in Co Down (3.1.1.).

Sexual dimorphism in size was calculated as a percentage (2.1.2). The extent of dimorphism in young and adult animals is compared (Fig.15). The minimum age for young stoats to be included in the

TABLE 6 BODY MEASUREMENTS OF IRISH STOATS

		n	Range	mean($\bar{x}$)	SE$\bar{x}$
BODY WEIGHT (g)					
Females	Young	9	85-206	149.2	3.940
	Adult	33	72-232	163.5	1.398
Males	Young	42	98-350	250.6	1.696
	Adult	66	138-442	328.2	0.925
HEAD AND BODY LENGTH (mm)					
Females	Young	13	201-272	232.2	1.789
	Adult	36	195-269	238.1	2.910
Males	Young	31	184-329	268.5	0.871
	Adult	70	242-355	283.5	0.274
TAIL LENGTH (mm)					
Females	Young	13	69- 95	83.2	0.599
	Adult	31	74-100	86.6	0.273
Males	Young	31	54-123	103.4	0.540
	Adult	74	72-127	118.0	1.208
HIND FOOT LENGTH (mm)					
Females	Young	13	37- 44	40.3	0.169
	Adult	34	28- 49	40.5	0.099
Males	Young	32	36- 55	46.5	0.271
	Adult	72	31- 55	49.6	0.059
EAR LENGTH (mm)					
Females	Young	13	18-21	18.6	0.077
	Adult	33	16-22	18.7	0.035
Males	Young	33	17-23	21.2	0.042
	Adult	63	18-25	22.1	0.023

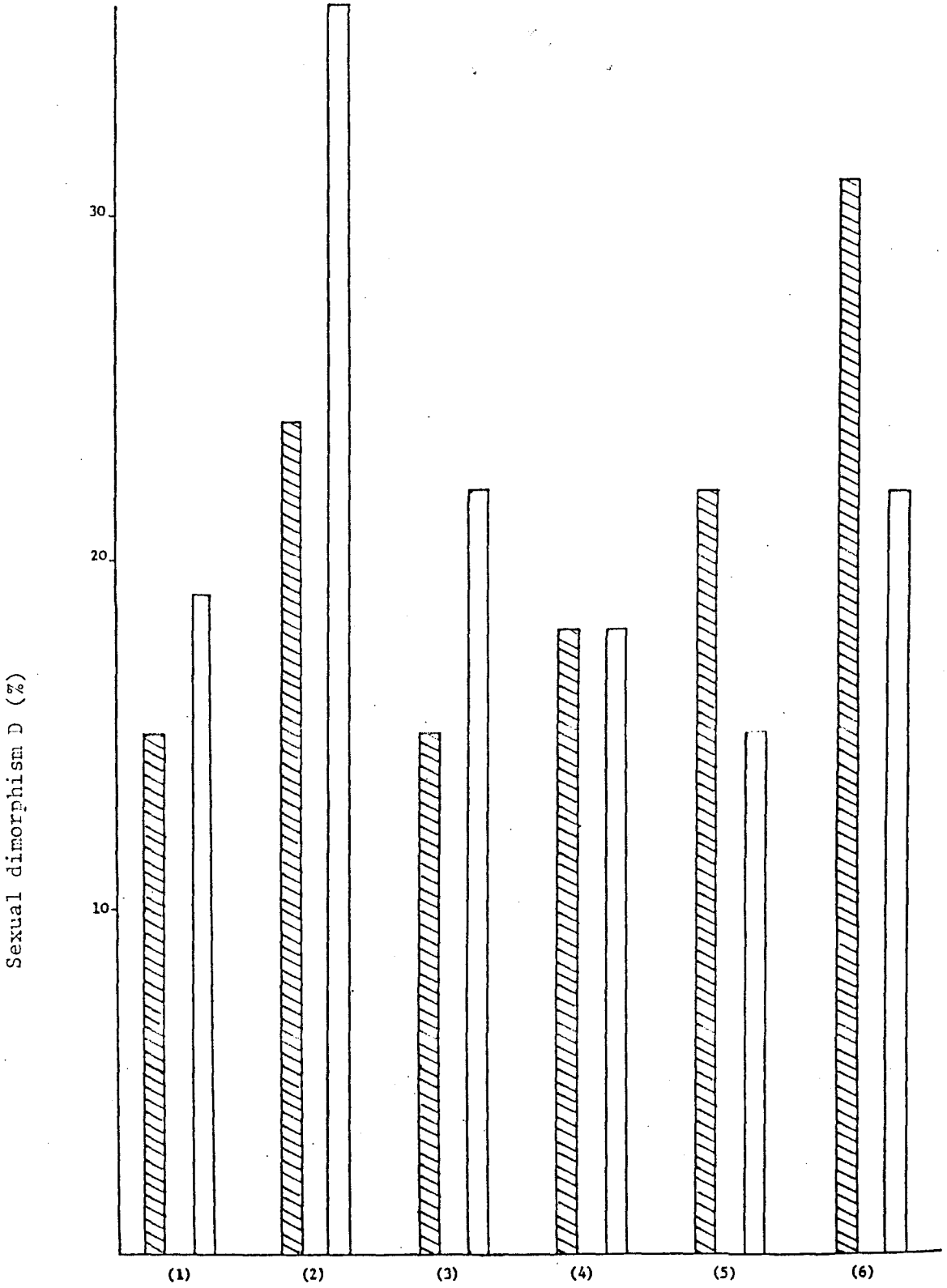
TABLE 7 SKULL MEASUREMENTS OF IRISH STOATS (mm)

		n	Range	mean($\bar{x}$)	SE$\bar{x}$
MANDIBLE LENGTH					
Females	Young	12	19-24	22.5	0.395
	Adult	31	21-24	23.0	0.229
Males	Young	30	23-28	26.7	0.052
	Adult	55	23-29	27.3	0.160
CONDYLOBASAL LENGTH					
Females	Young	3	36-39	37.6	0.415
	Adult	5	40-43	41.2	0.247
Males	Young	11	41-49	46.0	0.191
	Adult	15	44-51	47.7	0.125
ZYGOMATIC WIDTH					
Females	Young	3	19-22	20.6	0.415
	Adult	5	22-25	23.1	0.279
Males	Young	10	24-30	27.1	0.151
	Adult	18	25-30	28.3	0.077

symbols: n= number sampled and SE= standard error

adult group is much lower for females than for males (Fig. 11), however the comparison of size of adults and young is considered pertinent because females are known to grow faster than males (3.1.3). Sexual dimorphism increases with age for all the linear body measurements. However, skull measurements had either the same ratio of dimorphism in young and adults (mandible length) or greater dimorphism in young animals (condylobasal length and zygomatic width) (Fig.15). However, the overall number of complete skulls of young stoats was particularly low (i.e. only three, Table 7). All of these came from young females taken in Longworth traps in Co Down (Ulster) by W.I.Montgomery. Since stoats from Ulster are known to be smaller than those from elsewhere in Ireland (3.1.4) and Longworth traps would select for the smallest of these stoats there was obvious bias. Therefore the sexual dimorphism of young stoat skulls is greatly exaggerated and not an accurate reflection of overall dimorphism. Thus skull measurements have not been used here in calculations of average dimorphism referred to later (4.1.1).

Variation in ventral coat patterns was recorded from 231 stoat skins from Ireland, 163 collected during this study and 68 from various museums (Appendix 3:A) and is summarised in Table 8. Overall, 29 (13%) of the Irish stoats had a straight line pattern (Pattern A in Fig.2), like British stoats, whereas 202 (87%) had



Lengths of : (1) Head and body, (2) Tail, (3) Hind foot, (4) Mandible, (5) Condylobasal and (6) Zygomatic width

Figure 15. Sexual dimorphism in adult ▭ and young ▨ stoats

(for details see page 29)

irregular ventral patterns (Patterns B & C in Fig.2) like some weasels.

The extent of variation within these three arbitrary patterns of ventral coat is illustrated in Figure 16. The variation in Pattern A usually included the upper lips and sometimes throat patches being incompletely white. Only ten specimens (4%) had completely white upper lips and regular throat pattern, as in British stoats. Occasionaly some of the upper lip was white in Pattern B but rarely in Pattern C (Fig.16).

In discussing the distribution of ventral coat patterns between the sexes [and Irish provinces] Patterns B and C are combined, as the distinction is arbitrary [Tables 8 & 9]. The proportion of males with Pattern A is bigger than the proportion of females, the proportion of females with Patterns B and C is likewise bigger than males (Table 8). These differences are significant ($\chi^2 = 0.094$, $.80 < p < .50$).

The dorsal coat colour was not investigated specifically. However, no light-coloured ear tips were noted. The feet were frequently found to be white, with variation corresponding to that described by Fairley (1971). Occasional small white areas were found on the dorsal surface of the head, neck or back, but no white or obviously partially white stoats were found.

TABLE 8 VENTRAL COAT PATTERNS OF IRISH STOATS

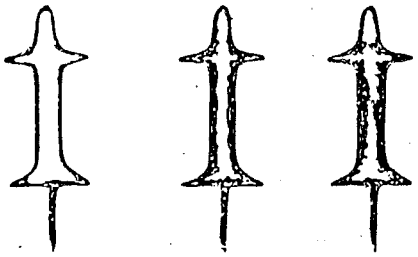
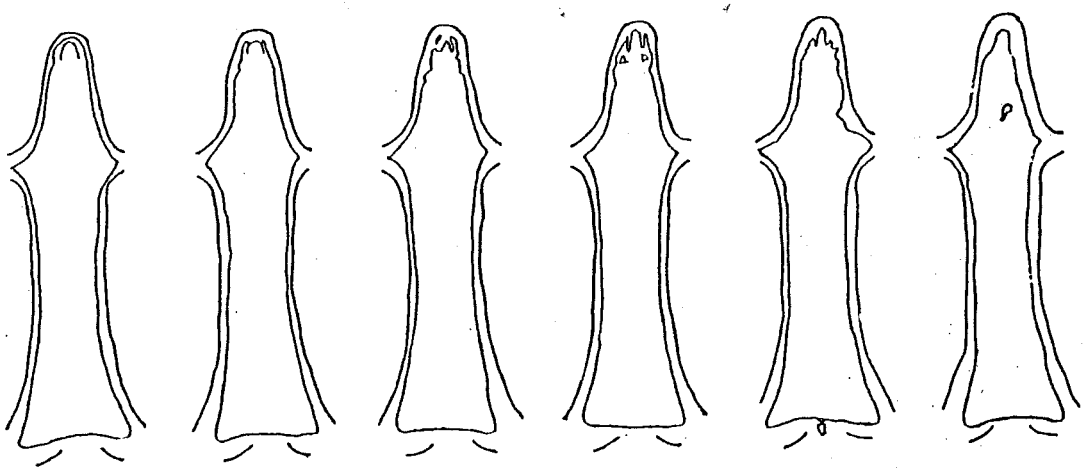
STOATS		COAT PATTERNS A	B	C	TOTALS
					
Male	No	20		134	154
	%	13		87	100%
Female	No	9		68	77
	%	12		88	100%

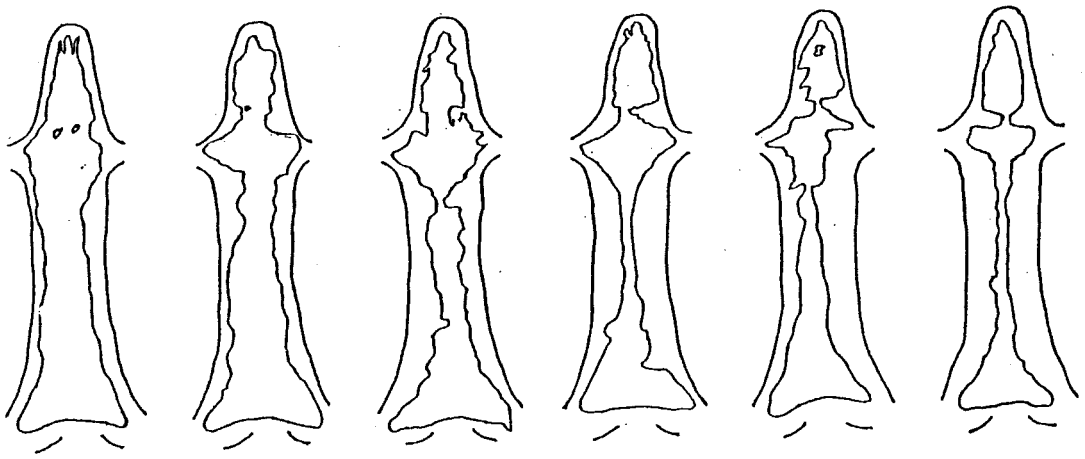
TABLE 9 GEOGRAPHIC VARIATION IN VENTRAL COAT PATTERNS OF IRISH STOATS

PROVINCE		COAT PATTERNS		TOTALS
ULSTER	No	2	34	36
	%	7	93	100%
CONNAUGHT	No	2	26	28
	%	8	92	100%
LEINSTER	No	4	26	30
	%	14	86	100%
MUNSTER	No	24	113	137
	%	18	82	100%

Pattern A



Pattern B



Pattern C

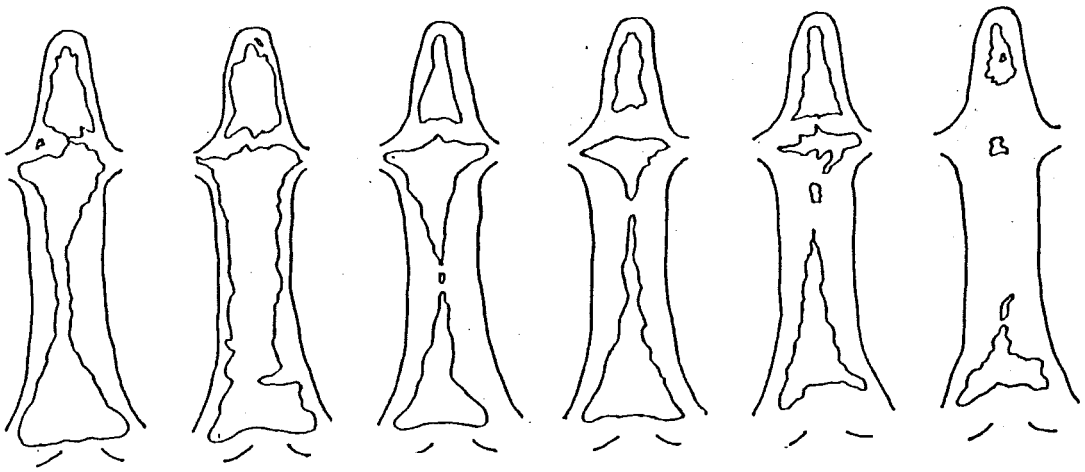


FIGURE 16. A REPRESENTATIVE SERIES OF VENTRAL COAT PATTERNS OF IRISH STOATS

3.1.5 Geographical variation

Two aspects of geographical variation were investigated: size and ventral coat pattern. Size was compared in stoats from different provinces, from vole and non-vole areas and from different distances south (see 2.1.2). All ventral coat patterns were compared from within each province and the distribution of one pattern (A) was examined separately.

The mean body measurements for adult stoats from each province differ (Table 10). The lengths and weights increase from north [Ulster] to south [Munster], reflecting the north/south cline in size (see Fairley 1981 & below). Males from the east [Leinster] are not significantly larger than those from the west [Connaught] when head-and-body lengths are compared, but when mandible lengths are compared there is a significant difference at $p < 0.05$ (Table 12).

Given that the sample size for mandible lengths is smaller than that for head-and-body lengths, it is probable that this difference in size of adult male stoats is more apparent than real. Previous analysis (see Fairley 1981) by partial regression failed to find evidence of an east/west cline. There were insufficent females sampled from Leinster and Connaught for statistical analysis of size differences to be made.

TABLE 10 MEAN BODY MEASUREMENTS OF ADULT STOATS FROM IRISH PROVINCES (±SE$\bar{x}$)

	Head & Body Length (mm)	Weight (g)	Tail Length(mm)	Hind foot Length (mm)	Ear Length(mm)
MALES					
ULSTER	262 ± 2.7	245 ± 9.7	87 ± 2.8	47 ± 0.6	–
CONNAUGHT	271 ± 1.5	283 ± 5.3	104 ± 0.7	46 ± 0.2	20 ± 0.2
LEINSTER	279 ± 1.2	335 ± 4.4	109 ± 1.0	46 ± 0.6	21 ± 0.2
MUNSTER	286 ± 0.4	415 ± 10.0	108 ± 0.1	49 ± 0.0	22 ± 0.0
FEMALES					
ULSTER	* –	* –	* –	* –	* –
CONNAUGHT	228 ± 4.0	160 ± 9.4	80 ± 0.0	39 ± 1.0	18 ± 0.1
LEINSTER	226 ± 2.9	150 ± 6.1	86 ± 1.6	40 ± 0.2	18 ± 0.0
MUNSTER	242 ± 0.5	180 ± 1.3	88 ± 0.3	41 ± 0.0	19 ± 0.0

* insufficent data

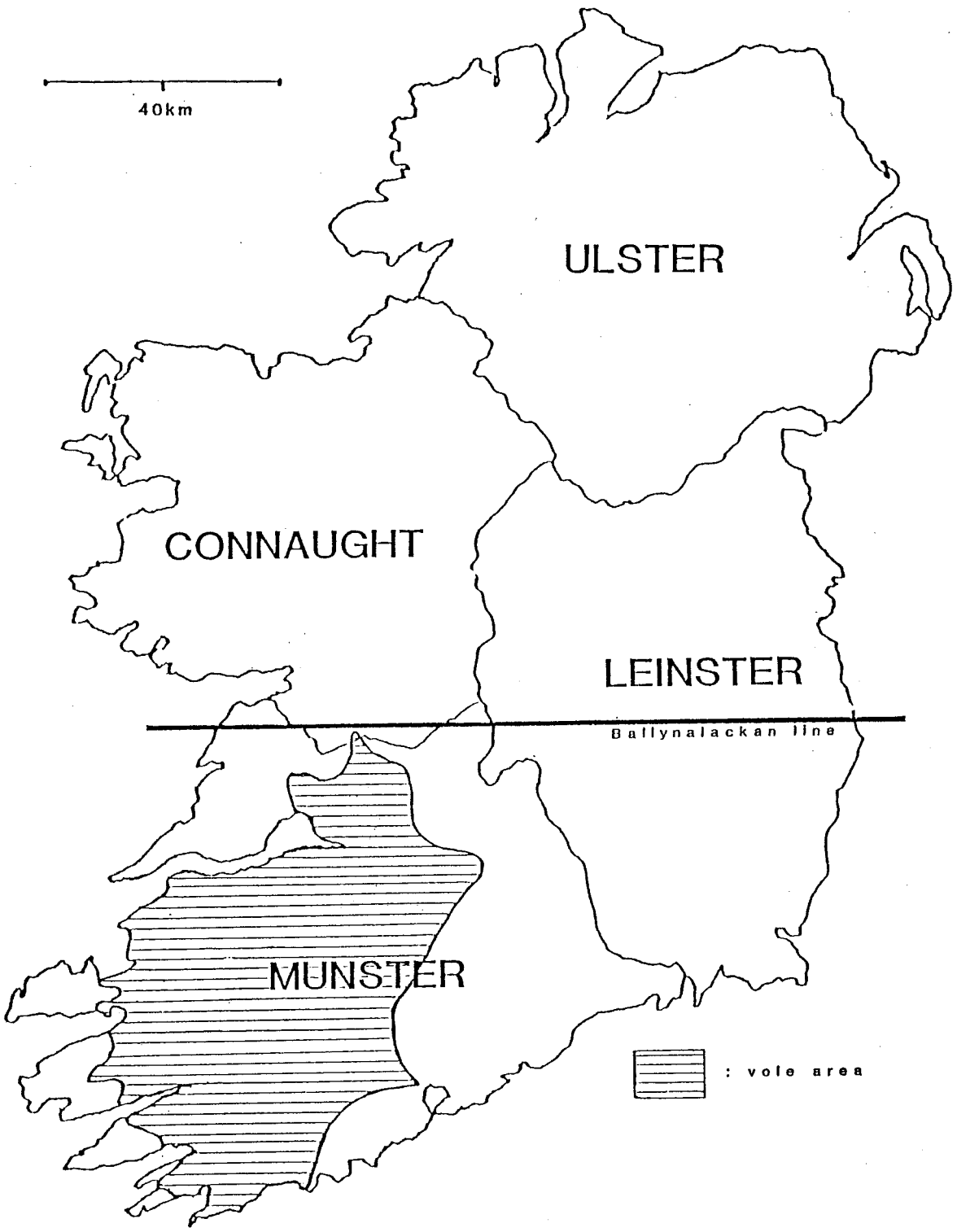


Figure 17. Ireland ,showing Provinces and approximate vole distribution (1985)

TABLE 11 COMPARISON OF SIZE OF ADULT MALE STOATS FROM LEINSTER AND CONNAUGHT

	n	mean	t	at P< 0.05
HEAD-AND-BODY LENGTH				
Leinster	10	279.2	0.19	not significant
Connaught	6	266.0		
MANDIBLE LENGTH				
Leinster	4	27.2	4.6	significant
Connaught	5	25.4		

TABLE 12 COMPARISON OF SIZE OF ADULT STOATS FROM VOLE AND NON-VOLE AREAS SOUTH OF THE BALLYNALACKEN LINE.

	n	mean	t	at P< 0.05
HEAD-AND-BODY LENGTH				
MALE				
Vole	23	285.8	0.35	not significant
Non-vole	33	287.8		
FEMALE				
Vole	14	240.2	0.44	not significant
Non-vole	14	242.6		
MANDIBLE LENGTH				
MALE				
Vole	22	27.4	0.68	not significant
Non-vole	27	27.6		
FEMALE				
Vole	13	23.0	1.50	not significant
Non-vole	13	23.6		

Results on the north/south size cline are shown in Figure 18, size poltted against distances south of Malin Head. It was found that regressions done on this data did not show that distance south predicted size [goodness of fit tested using an F test: none were significant}. This is considered to reflect the lack of specimens from Ulster, as there is clearly a north/south size difference overall, the stoats in the south being bigger.

No significant difference was found (Table 12) between size of adult stoats from vole and non-vole areas south of the Ballynalacken line (see 2.1.2 & Fig.17). Similarly, no significant difference in size was detected between stoats from woodland habitats in vole and non-vole areas, despite what might be expected as woodland is preferred habitat of these voles (Appendix 5:D; 4.2.2).

Geographical variation in ventral coat pattern is not as marked as in size. Pattern A is found most commonly in the south of the country, although there are records from the north. Patterns B and C [combined here] are found all over the country (Fig.19). It is possible that the apparently high frequency of Pattern A in the south simply reflects the bigger sample size from the south (see Fig.6). Analysis using chi-squared tests on the percentage of Patterns A to B & C occurring in each province (Table 9) showed

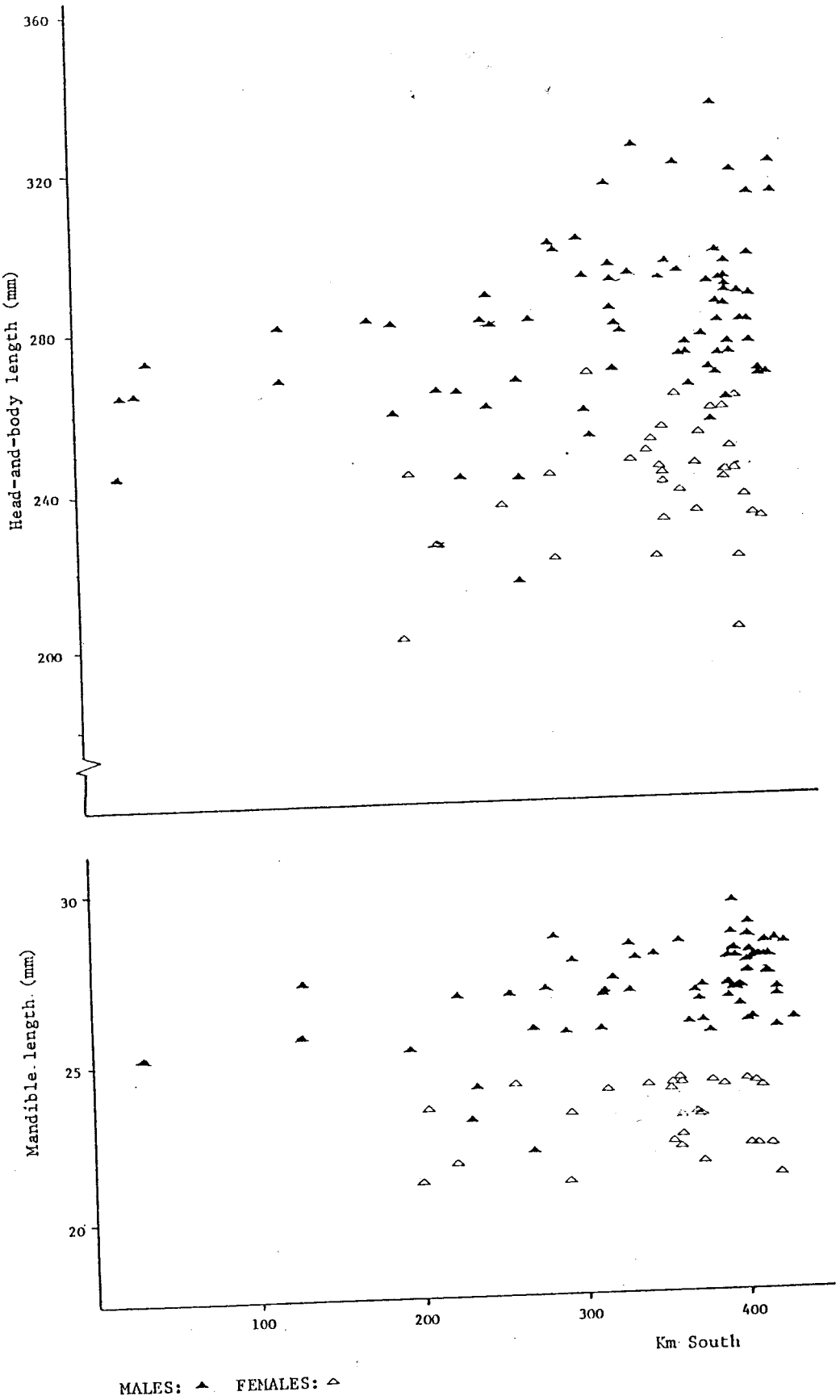
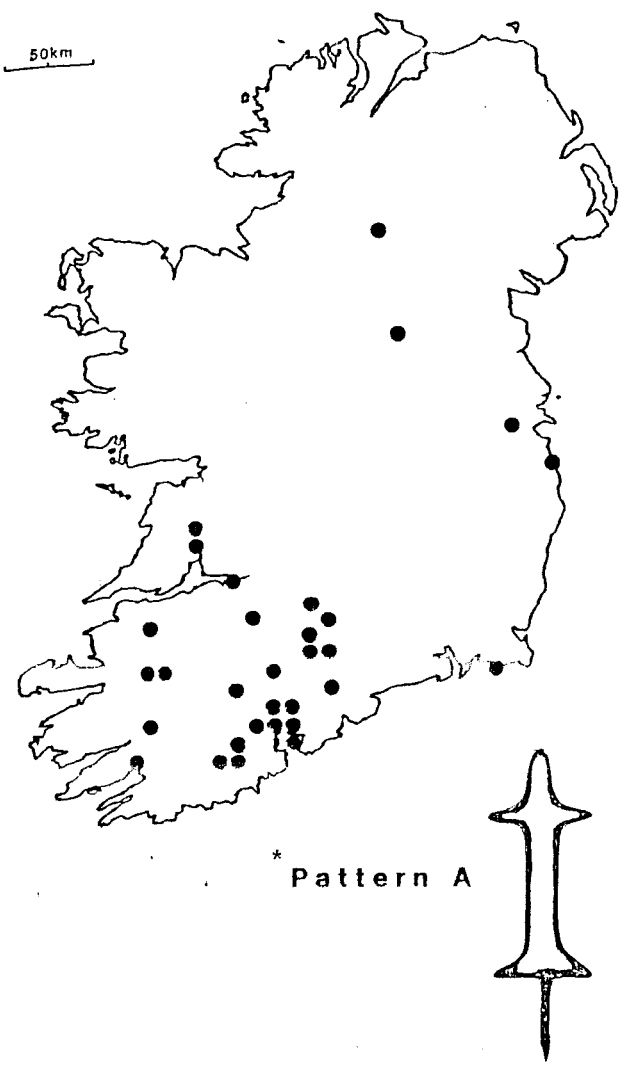


Figure 18. Head-and-body and mandible lengths of adult male and female Irish stoats plotted against the distance south from Malin head.

that there are differences between each province (also see Appenidix 3:D). However the most significant difference (χ^2=16.5 p < 0.001) was between Ulster and Munster. This results from a much greater proportion of Pattern A in Munster, than in Ulster, and to a lesser extent Connaught (χ^2= 6.71, 0.027 > p > 0.01) and Leinster (χ^2= 1.07, 0.20 > p > 0.10). The ten specimens with totally white upper lips (3.1.5) were also all from Munster.



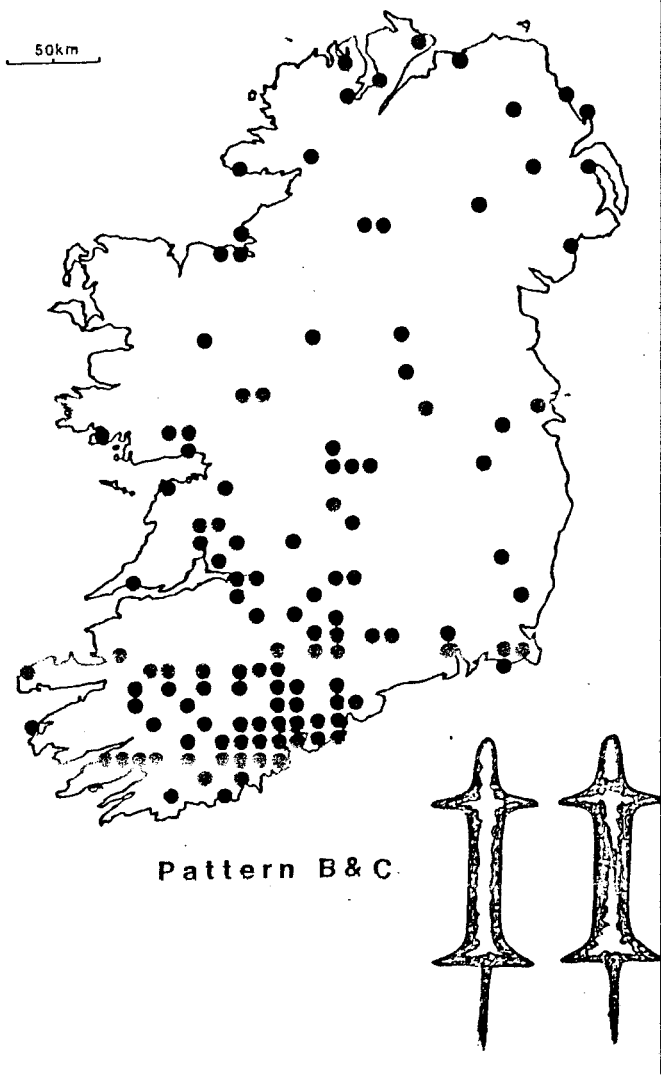


Figure ~~19~~. Distribution of stoat coat patterns

* In addition there is an unspecific record of pattern A from Co Antrim (National Museum no 115.1895)

Fig 2

3.1.6 Summary

A total of 196 stoats from Ireland were sampled during this study, along with three from the Isle of Man. This does not include the musuem specimens examined (Table 2). Although the stoats came from all over Ireland the majority were from the south. They were usually victims of traffic accidents, which caused many (89%) to have broken skulls and no abdominal viscera. The road casualties were mainly male stoats and the seasonal distribution of such casualties is thought to reflect the seasonal increases in home range of adults and dispersion of young. Road casualty mammals have previously been used for studies in Ireland (e.g. Ní Lamhna 1979; Sleeman 1979) but they have never been such a central part of a single study. Trapped stoats, stoats killed by predators, and others whose cause of death was unknown, were also part of the sample.

The life-cycle indicated by the study of this sample is as follows. There is a distinct breeding season from March to mid-August. The young are born around early April and the presence of lactating females indicates that young are suckling in April, May, June and early July. Mid-August to March is a period of sexual quiescence for both sexes. These results agree with those of the only previous study by Fairley (1971).

Historically there has been some controversy about reproduction in the Irish stoat. Scharff (1909) reported nine young (embryos) from an Irish stoat and considered this to be evidence that they were more prolific than other stoats. Barrett-Hamilton (1909) immediately challenged this view and stated that 2-13 young had been recorded in Germany, England and Scandinavia. Similarly Miller (1912) stated that Irish stoats had more numerous nipples (10-12 in contrast to 8) which has since been quoted as a particular characteristic of the Irish stoat (e.g. Matthews 1952; Southern 1964). Fairley (1971) examined seven Irish stoats with visible nipples. These had four or five pairs (mean= 9.1, SE=0.09) and he concluded, quoting Deansley's (1935) data for British stoats of four to six pairs, that Irish stoats did not have larger numbers of nipples than other stoats. The mean number of nipples found in this study was 9.7 (SE=0.07) which agrees with his conclusion.

Growth in the Irish stoat is rapid, there is no significant difference between the size of adult and young males from August onwards. Females appear to reach adult size even earlier, no significant difference being detected between adults and young females from July. Therefore skeletal size of adults and most of the young sampled is similar, indicating that food supply in the first months of life may be a major factor in determining size.

Overall size measurements reflect geographic variation of the stoat within Ireland, stoats becoming smaller further north. Given the somewhat unexpected, but marked, geographical size variation in the Irish stoat, it can readily be understood why mistakes were made in earlier studies when samples came from a limited area as discussed in section 1. Despite what might be expected no significant difference was found between the sizes of stoats from vole and non-vole areas.

In the overall sample of ventral coat patterns 13% of the Irish stoats had type A pattern, like British stoats. The distribution of ventral coat patterns suggests that there are more stoats with British stoat type ventral pattern in Munster than in the rest of the country. Also all ten (4% of overall sample) specimens with totally white upper lips were from Munster. These facts could be interpreted as evidence suggesting an introduction of such stoats into Munster.

3.2 HABITAT UTILISATION

3.2.1 Stoat trapping and tagging

In all, six stoats were live-trapped at Fota (Table 13). These are considered separately from the rest of the study and are not therefore included with the 15 stoats trapped elsewhere. The first live trapped stoat escaped and is not dealt with hereafter. The second [No 2] was captured twice but as she was heavy with young on the first occasion, and was considered to have recently had her young on the second, she was not radio-tagged. The remainder (three females and a male) were all radio-tagged (Table 13 & 14). The four females captured were all caught in traps baited with male anal scent gland secretions. The only male was caught in a trap baited with cat food. Live traps baited with rabbit guts caught no stoats (Appendix 10:C).

Swedish research has shown that subdominant stoats (often transients) when faced with a conspecific scent gland secretion will retreat whereas dominant (residents) will advance (Erlinge 1977c). hence the animals trapped using scent bait in this study were likely to be residents. It is now known that there are individual differences in stoat anal scent gland secretions and that such secretions play an important role in stoat social organisation (Erlinge, Sandell & Brink 1982).

TABLE 13 LIVE-TRAPPED STOATS AT FOTA, 1985

No	Sex	Status	Weight (g)	Date/Time	Location	Prey identified from scats	Radio-tag
1	?	?	?	14 Feburary Morning	Wildlife Park	None	None
2	♀	Adult	210	10 April Morning	" "	Shrew	None
"	"	"	175*	12 April Morning	" "	Rabbit	None
3	♀	Adult	195	21 May Evening	House Wood	Wood mouse	Fitted
"	"	"	Not taken	7 July Evening	Railway Wood	Shrew	Fitted
4	♀	Young	225	20 August Evening	Wildlife Park	None	Fitted
5	♀	Young	220	24 October Evening	Railway Wood	Shrew & Rabbit	Fitted
6	♂	Unknown	250	15 November Evening	Quarry Wood	Shrew	Fitted

* It is likely that this female gave birth between April 10 and 12th (Appendix 7E)

TABLE 14 RADIO-TRACKED STOATS AT FOTA, 1985

No	Sex	Month and duration	Home range area (ha)	Total no of fixes	Location Fig.3 & 16	No of dens detected Fig.20-23
3	♀	May 12 days	15	14	Railway Wood	3
		June 30 days	17	40	" "	7
		July 30 days	22	44	Railway & House Woods	5
4	♀	August 8 days	10*	12	Wildlfe Park	3
5	♀	October 6 days	2*	7	Railway Wood	1
6	♂	November & December 20 days	11*	24	Quarry Wood	3

* these home ranges considered incomplete

The radio-tagged stoats were tracked for periods of 72, 8 and 6 days (females) and 20 days (male) (Table 14). Stoat No 3 was an adult female, referred to here as "Sally". She was lactating when captured and presumably had young in a nest. During radio tracking therefore she was probably nursing and fending for her young. The other two females were young and the age status of the male is unknown as there is no simple field method of distinguishing adult from young males in November (2.2.3).

3.2.2 Trapping of other species

Small mammals are an important part of the stoat's diet, therefore efforts were made to ascertain presence or absence of small mammals (in particular voles) by trapping with breakback traps (2.2.1). At Fota during the year's field work, 206 breakback trap nights were logged yielding 56 woodmice and no other species (Appendix 10:B). Fota can be regarded as a non-vole area at this time (1985). In the stoat live-traps at Fota, 44 woodmice and nine common rats were trapped (Appendix 10:C). Both species, but in particular rats, damaged the traps by gnawing (Plate 2A).

Fenn trapping for stoats also caught 25 rats and three domestic cats (Appendix 10:A). These rats provided records of ectoparasites

(Appendix 6:D). Breakback trapping at the Fenn trapping sites and other areas in Co Cork totalled 341 trap nights. These yielded three voles, 16 woodmice, a shrew and a house mouse. These trapping results (Appendix 10: A & D) were used to supplement available information on vole distribution (see Figure 17).

3.2.3 Habitats

General habitats are divided into four broad types: wooded country, open country, urban/suburban and seashore (2.3.1). The numbers of records of stoats from different habitat types are shown in Table 15. It is evident that two habitat types; wooded and open country were the predominant habitats of stoats. For historical reasons less than 4% of Ireland's total area is wooded (McCracken 1971), making it a relatively scarce habitat in comparison to other countries in the stoat's geographic range. Many of the woodland habitats recorded would be isolated and unmeasured. The data can be taken as some indication of where people have seen stoats, dead or alive.

Of the radio-locations from stoats on Fota 86% were from woodland (Table 15). The question arises as to whether this is because woodland is so common at Fota. Using a chi-squared test, the expected occurrence in available habitats (using known area of habitats available) was tested against that observed (Table 15). The results showed a highly significant preference for woodland ($\chi^2 = 280.8$. $p < 0.001$), which clearly shows that woodland was chosen disproportionately often when compared to its availability. All successful captures in live traps were also in woodland habitat (Figure 20).

3.2.4 Minor Habitats

Radio-location and surveillance allowed more detailed observations on stoat minor habitats (see 2.2.4 & 2.3.1). In woodland these were divided into: arboreal; underground and in cover. Similar divisions were used for open area minor habitats (Table 18). Most of the fixes (60%) were underground in woodland. The majority of these were from rats holes (54%) however, a significant proportion (23%) were from rabbit holes and some (5%) were from woodmouse holes (Table 19). Activity, probably hunting, was recorded several times underground, often in rat holes.

Arboreality was detected in all radio tagged stoats except one, a young female (Table 18). Trees were used in both woodland and in open areas [open parkland on Fota had scattered individual trees], and once as a den by the breeding female Sally (Table 20). Tree species used were:- lime 10 fixes; decidous oak 3 fixes; ash (Fraxinus excelsior), holm oak (Quercus ilex), yew (Taxus baccata), Scots pine (Pinus sylvestris) and sycamore (Acer pseudoplatanus) one fix each. All the limes used had a characteristic growth of a maze of twigs at 2 to 3m from the base. This dense branching, sometimes referred to as witch's broom, is typical of the broad-leaved limes. It was in this "maze" that the stoats were located. All the other trees with the exception of the yew,

TABLE 15 NUMBER OF RECORDS OF IRISH STOATS FROM DIFFERENT HABITATS

HABITAT	This study: Road casualty records No	%	This study: Trapping & sighting records No	%	Irish Biological Records Centre records No	%	All Records No	%
Wooded Country	35	34	30	45	175	49	240	46
Open Counrty	56	54	21	32	146	41	223	42
Urban/Suburban	8	8	4	6	6	2	18	4
Seashore	4	4	11	17	29	8	44	8
Totals	103	100%	66	100%	356	100%	525	100%

TABLE 16 NUMBER OF RADIO LOCATIONS OF STOATS IN AVAILABLE HABITATS AT FOTA (see 2.3.1)

	Available habitats (percentage of total available area) Woodland	Non-woodland
Hectares available	100 (32%)	216 (68%)
*Expected number of radio-locations	42	89
Observed number of radio-locations	111	20

$\chi^2 = 280.8$ $p << 0.001$

* Calculated from the % of habitat available (2.3.1).

TABLE 17 NUMBER OF RADIO-LOCATIONS IN VARIOUS HABITATS

HABITATS		STOATS									
		Female						Male			
		Stoat No 3		Stoat No 4		Stoat No 5		Stoat No 6		TOTAL PER HABITAT	
Major	Minor	No	%	No	%	No	%	No	%	No	%
Woodland	Arboreal	7	8	/	/	/	/	3	14	10	8
	Underground	53	60	7	58	1	15	18	77	79	60
	Cover	15	18	3	25	2	28	2	9	22	17
	% Woodland		86		83		43		100		86
Open Areas	Arboreal	4	4	/	/	4	57	/	/	8	6
	Underground	3	3	/	/	/	/	/	/	3	2
	Pasture [+ reeds]	4	4	2	17	/	/	/	/	6	5
	Hedges	3	3	/	/	/	/	/	/	3	2
	% Open areas		14		17		57		/		14
TOTAL PER STOAT		89	100%	12	100%	7	100%	23	100%	131	100%

had at least one clinging epiphyte (ivy or Clematis) and it was usually in the densest part of this that the stoat was located. Estimates of the actual height off the ground based on the angle and strength of signal were from between 2 and 10m.

3.2.5 Dens

Applying the definition of den used in this study (2.3.1), a total of 19 dens were identified (Table 19). Usually these dens had been taken over from another species, frequently the common rat. Other identified den sites were in rabbit and woodmouse holes, in a lime tree while four were in piles of sticks and/or stones (Table 20). Most of these dens (12 out of 19) were occupied by Sally and therefore might be regarded as breeding dens. The dens were foci of activity within the home range (3.2.6 & Figures 20 & 21).

TABLE 18 NUMBER OF RADIO-LOCATIONS FROM VARIOUS UNDERGROUND MINOR HABITATS

HABITATS	STOATS					
	FEMALES			MALE	TOTALS	
	Stoat No 3	Stoat No 4	Stoat No 5	Stoat No 6	No	%
Unidentified hole or pile of stone or wood	10	1	/	4	15	18
Rat hole	31	3	1	9	44	54
Rabbit hole	14	/	/	5	19	23
Woodmouse hole	1	3	/	/	4	5
LOCATIONS PER STOAT	56	7	1	18	82	100%

TABLE 19 NUMBER OF IDENTIFIED DEN SITES

Unidentified hole or pile of stones or wood	3	/	/	1	4	21
Rat hole	5	2	/	2	9	48
Rabbit hole	3	/	/	1	4	21
Woodmouse hole	/	1	/	/	1	5
Lime tree	1	/	/	/	1	5
DENS PER STOAT	12	3	/	4	19	100%

3.2.6 Home range

The recorded home ranges for each radio-tracked stoat are illustrated in Figure 20. The area as calculated from an increasing number of radio-locations was plotted (see Hill & Robertson in press). The estimated home range area became relatively stable in only one stoat, Sally at 24 locations, although it continued to increase slowly with increasing numbers of locations (Fig.21).

Tracking of the other two females radio-tagged (No 4 & 5 5) did not provide a stable estimate of home range (Fig.21) therefore their home ranges should be regarded as incomplete . The male (No 6) had 24 locations but as the area had not stabilised, its home range should also be regarded as incomplete.

The home range of Sally, a lactating female who was presumably feeding young, increased in size over the three months of tracking. In May the range was 15ha, in June 17ha and in July 22ha (Figure 21). The home range is therefore regarded as 22ha (Table 14). This relatively large home range is considered to be associated with increased nutritional needs of both Sally and her putative young.

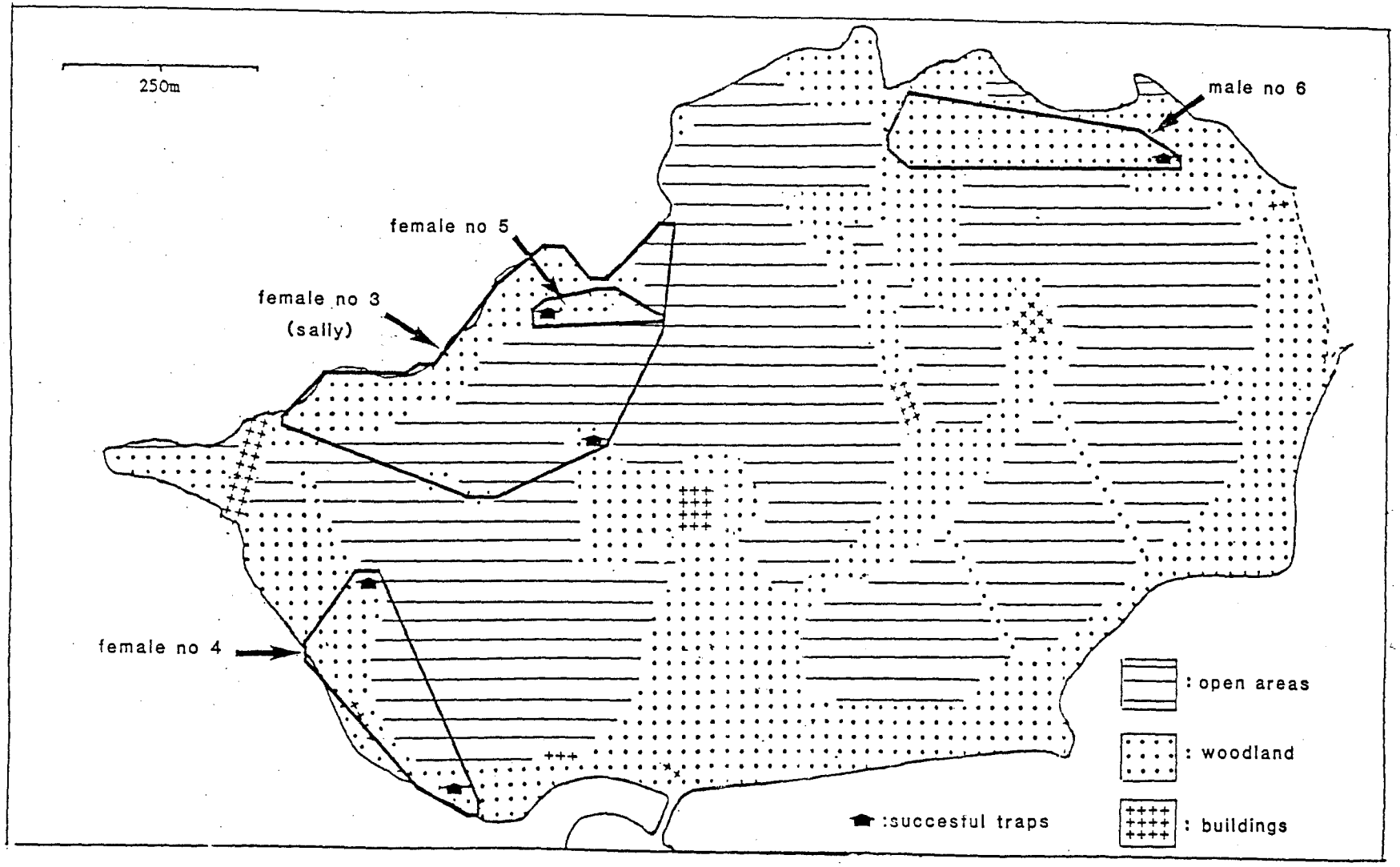


Figure 20. Stoat home ranges and succesful traps on Fota.

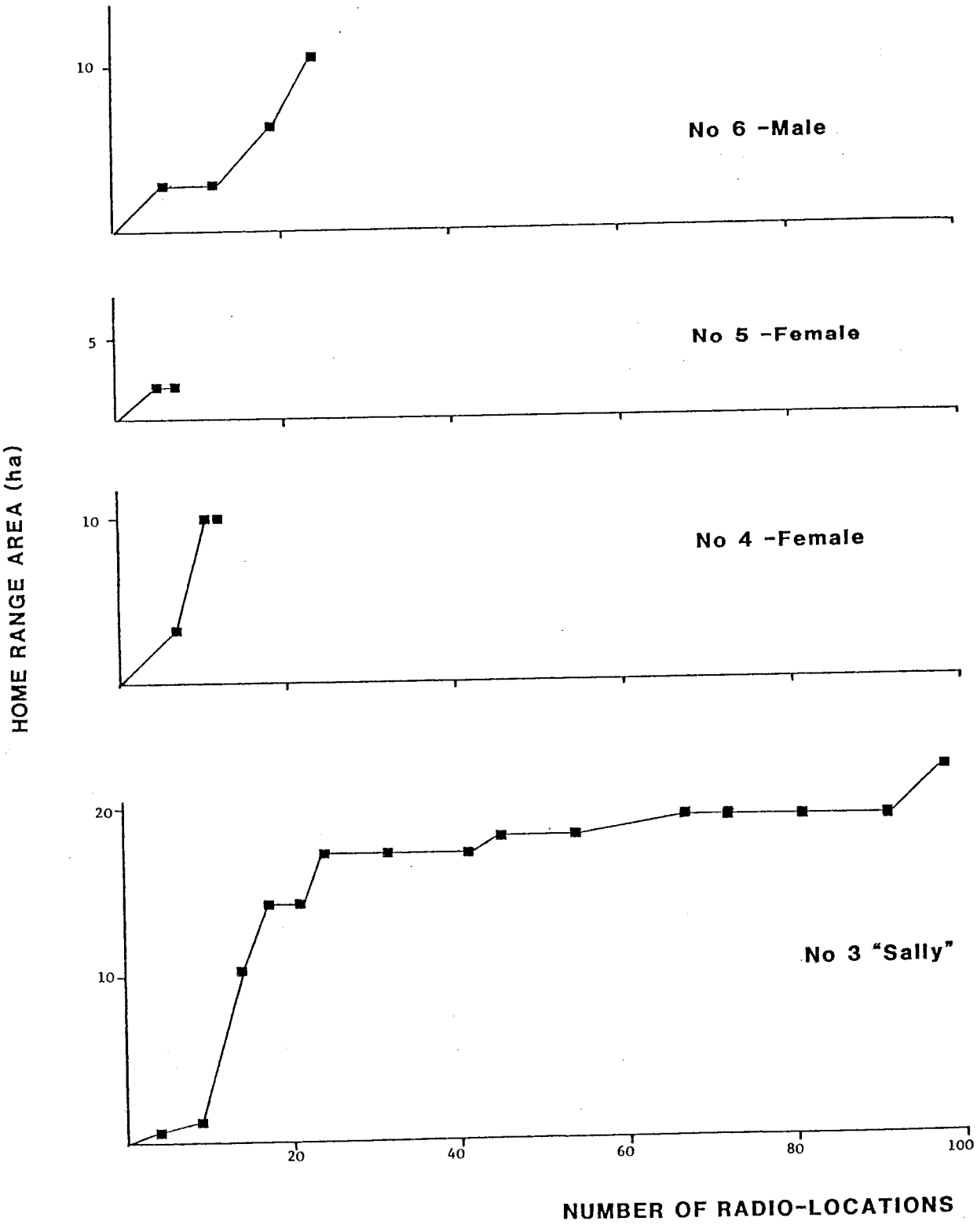


FIGURE 21. HOME RANGE AREAS AS CALCULATED FROM AN INCREASING NUMBER OF RADIO-LOCATIONS

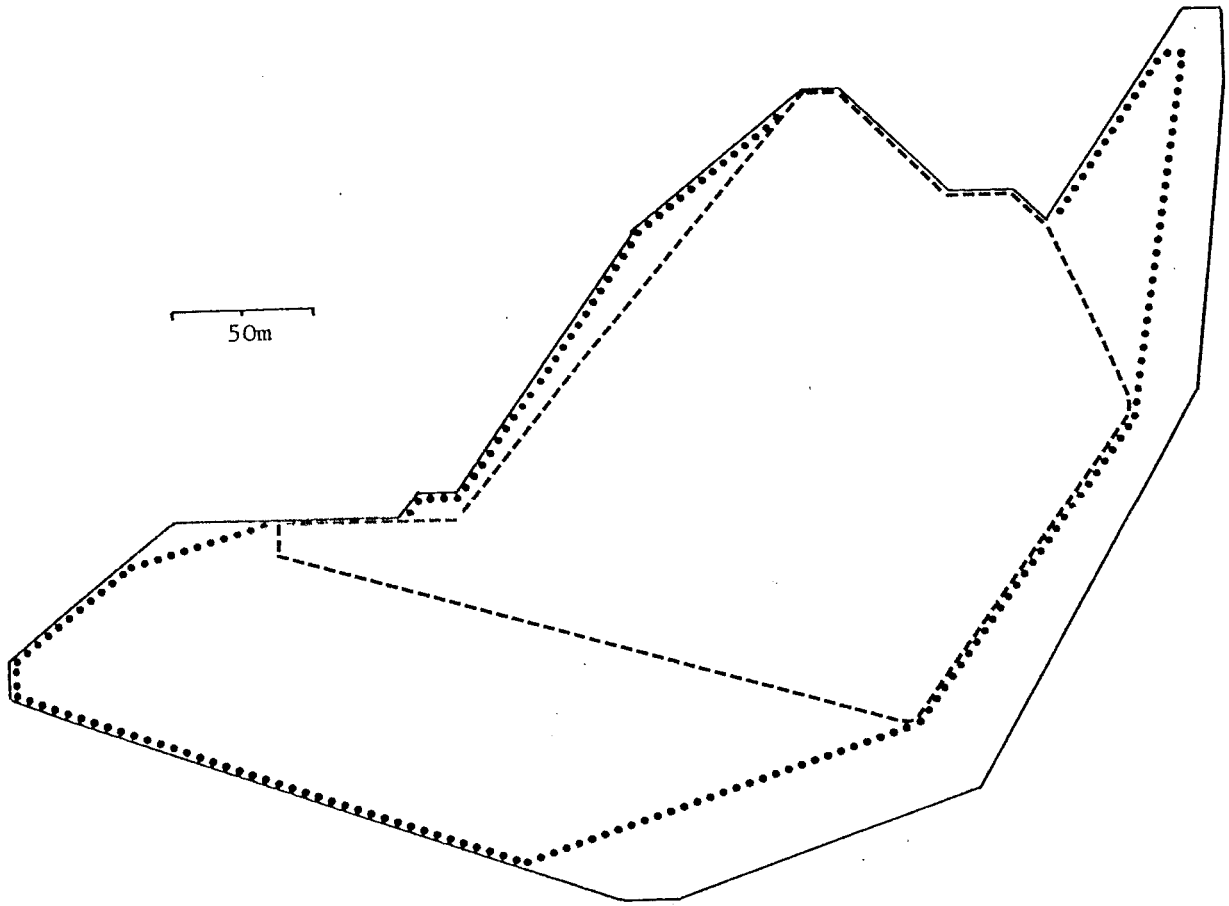


Figure 22. Home range per month (cumulative) of stoat no 3 in May ----- , June ..... , and July —— 1985

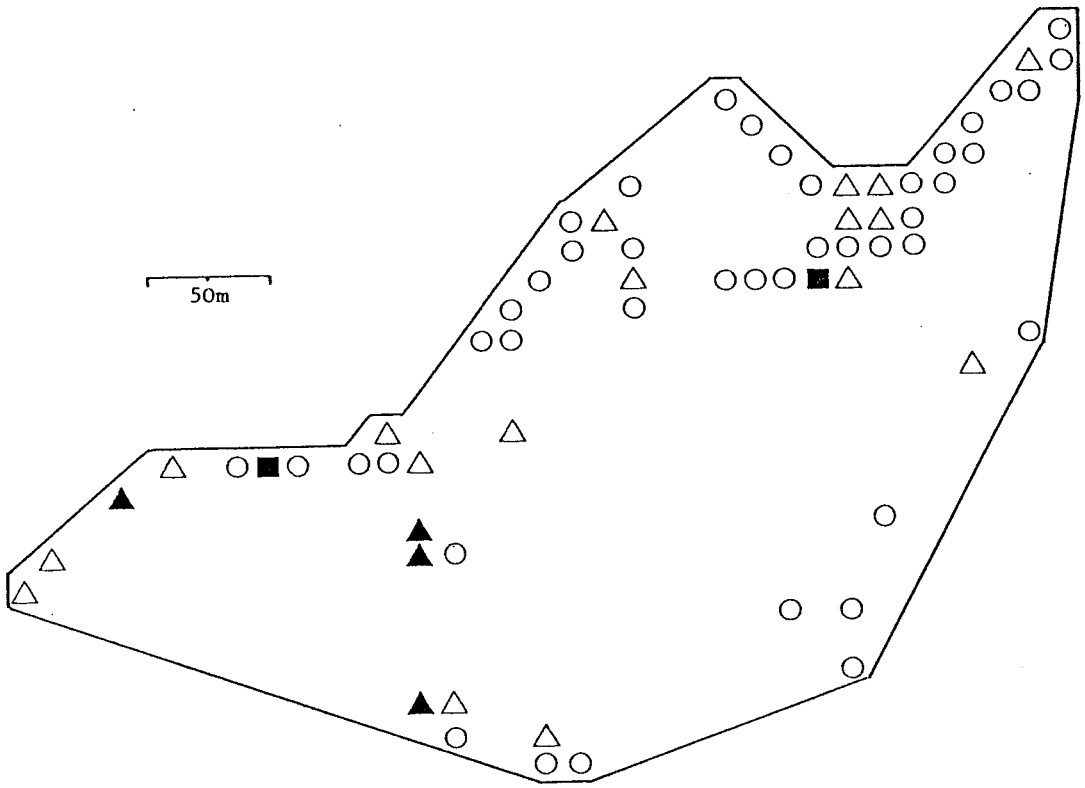


Figure 23. Home range utilisation by stoat no 3 (Sally)

Differential use of each cell is indicated by the symbols ○: 1 location △: 2-3 locations ▲: 4-5 locations ■: 6+ locations

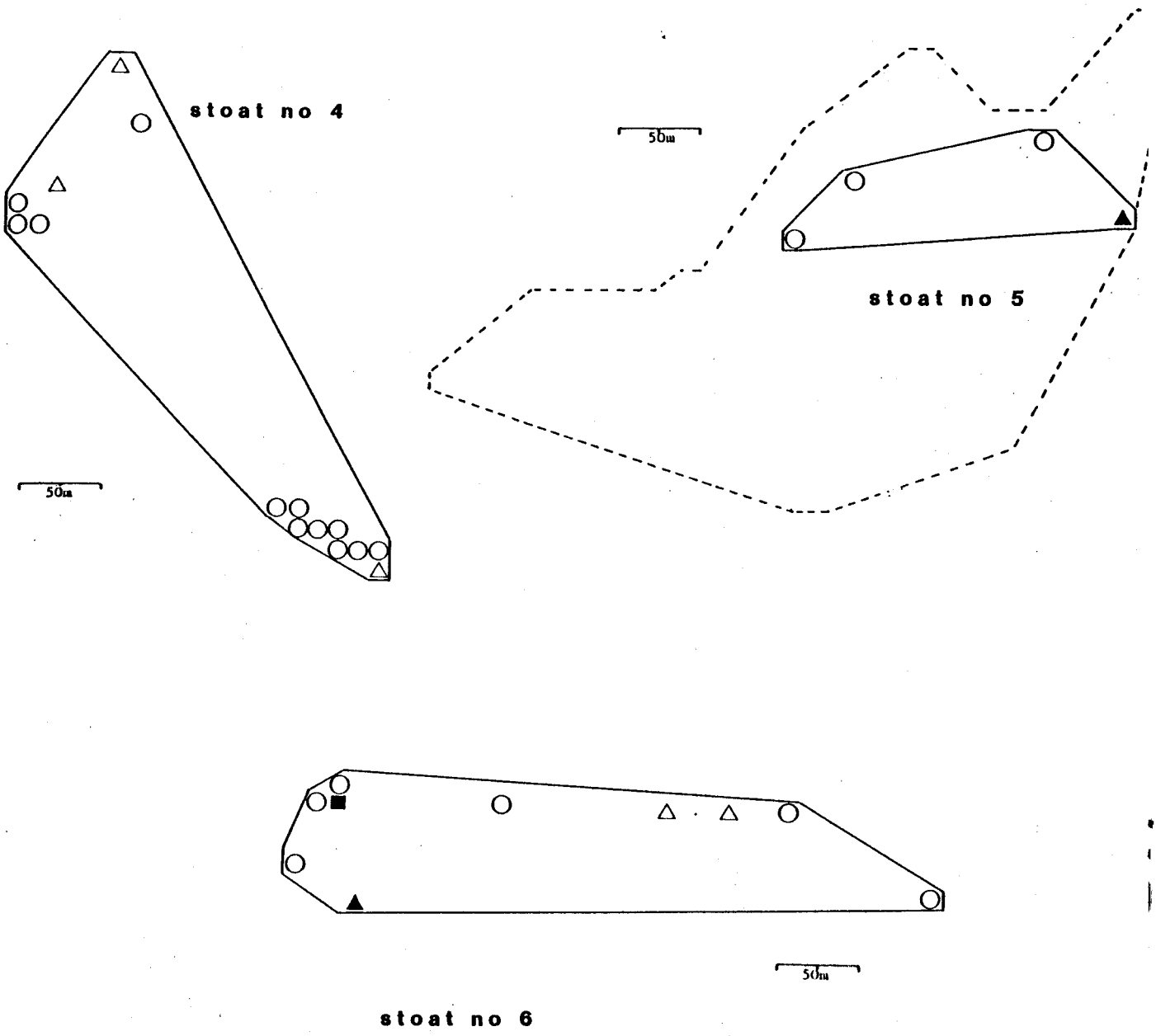


Figure 24. Home range utilisation by stoats no.s 4 &5 (females) and no 6 (male). -symbols as in Figure 23.

The broken line around the home range of no 5 is the range of stoat no 3 (Sally)

The remainder of the home ranges recorded are considered incomplete (see above). For female No 4 [a young female], the home range area was 10ha, measured over 8 days. Another young female, No 5 had a home range of 2ha measured over 6 days. Finally, the male No 6 of unknown age had a home range of 11ha measured over 20 days (Table 15).

Stoat utilisation of the home ranges was uneven, most time being spent around dens in woodland. It is evident that the animals spent most of their time at the edges of their home range (Figs. 22 & 23), and this coupled with observations of suspected boundary patrolling (e.g. Fig.24 July 1-14) suggests that the stoats were defending territories, as has been found elsewhere (Lockie 1966; Erlinge 1977b).

The stoats were radio-tracked at different times. Nevertheless it is of interest that only once did the ranges overlap where the range of stoat No 5, a young female, was completely enclosed within the earlier recorded range of Sally [No 3](see Figs. 20 & 24). It is considered likely that No 5 took over that part of the home range of No 3 due to the latter's absence and/or death. Indeed it is reported from Sweden that young females tend to remain in their mother's home range (Erlinge 1977a), and it is possible therefore that Sally was the mother of No 5.

3.2.7 Movement and behaviour

Type [a] movements were only observed in three of the radio-tagged stoats, stoats No 3,4, and 6 (Table 20, Figs.25-26). These were best studied for Sally, the stoat tracked longest. The mean observed distance of type [a] movements was 55m. The mean distance of such movements for Sally increased between June and July (Table 20) as did her DMD over May, June and July (Table 21 & Fig.27). Both mirrored the apparent increase in size of her measured home range (Table 14) over these months.

The stoats' use of cover was so adept that despite the fact that the radio tag indicated the stoats' postions they were rarely seen (11 sightings in 106 days). Radio-tagged pine marten in Co Clare were also rarely seen for the same reasons (P.O'Sullivan-pers.comm.). Radio-survellance provided little information as the animals could rarely be seen. The stoats tended to move swiftly across open ground but slowly in cover.

However radio-surveillance did provide some observations on stoat behaviour. Sally and the male (No 3) were observed climbing trees. The animals moved along the branches and up and down tree trunks in a squirrel-like manner, their claws sometimes being audible scraping against the bark. Sally was also observed raiding the

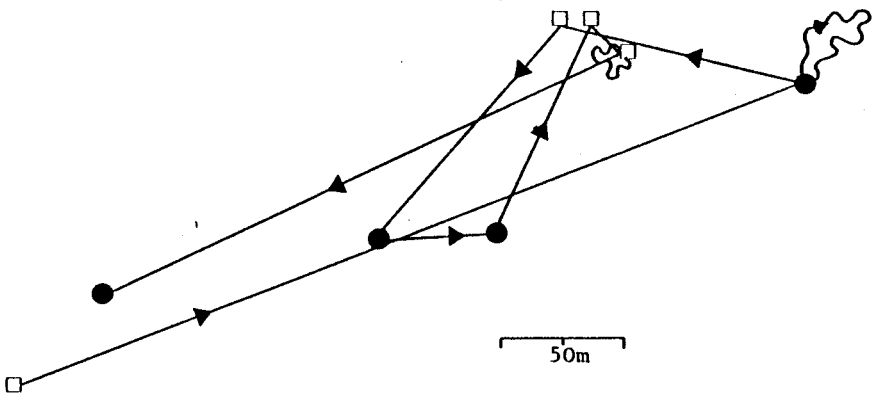
TABLE 20 SMALL-SCALE MOVEMENTS FOR STOATS NUMBERS 3,4 AND 6.

Stoat	Month(s)	Number of movements observed	Nocturnal or Diurnal	Range of distances	Mean distance (±SE$\bar{x}$)
No 3 (Sally)	May	2	Diurnal	50 - 200m	125m (±37.5)
	June	12	Diurnal	1 - 150m	25m (±3.3)
	July	11	Both	2 - 400m	86m (±10.8)
No 4	August	4	Both	3 - 150m	52m (±11.8)
No 6	November	5	Both	1 - 150m	32m (±11.8)
	TOTALS	34		1- 400m	55m (±2.53)

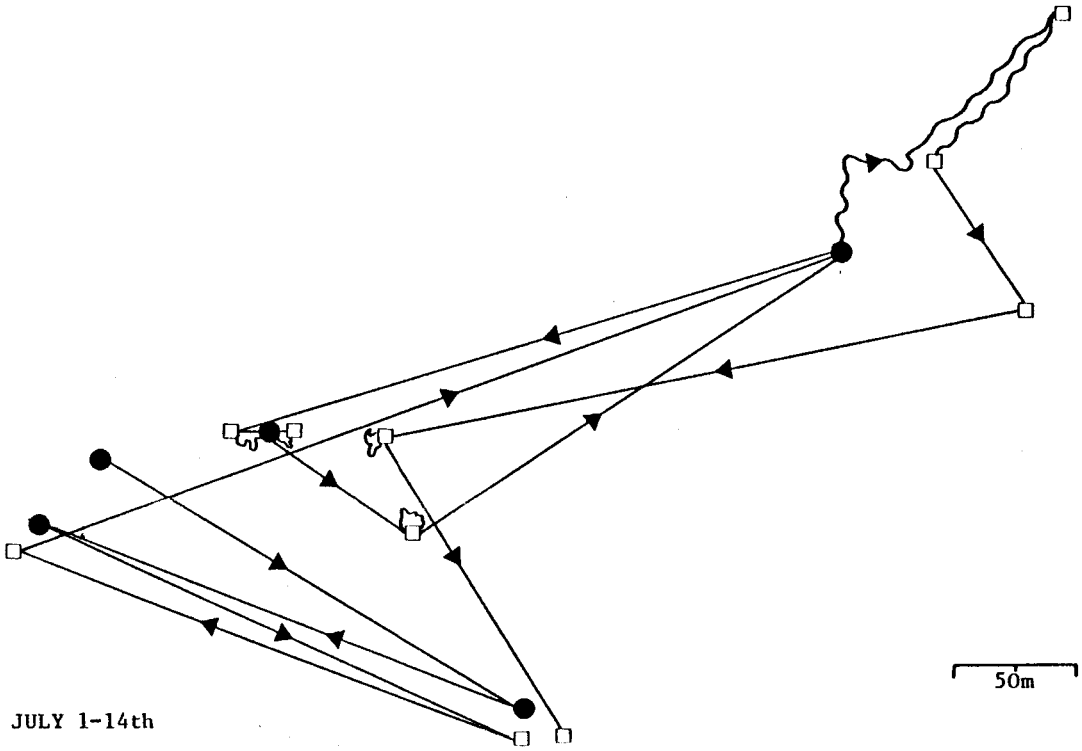
TABLE 21 MEAN DAILY MOVEMENT DISTANCES(m) FOR EACH RADIO-TRACKED STOAT [$\bar{x}$, ± Standard Error]

Stoat	May n	May mean	June n	June mean	July n	July mean	Total n	Total mean
No 3 [Sally]	11	124(±37.4)	19	313(±56.7)	19	419(±69.7)	49	345(±38.0
	August							
No 4	5	305(±157.2)						
	October							
No 5	5	108(±57.8)						
	November & December							
No 6	10	250(±81.6)						

nests of three different species of birds (3.3.1). Also stoat No 4 was seen stalking a rabbit and systematically searching a rat-infested haystack, both in the Wildlife Park.



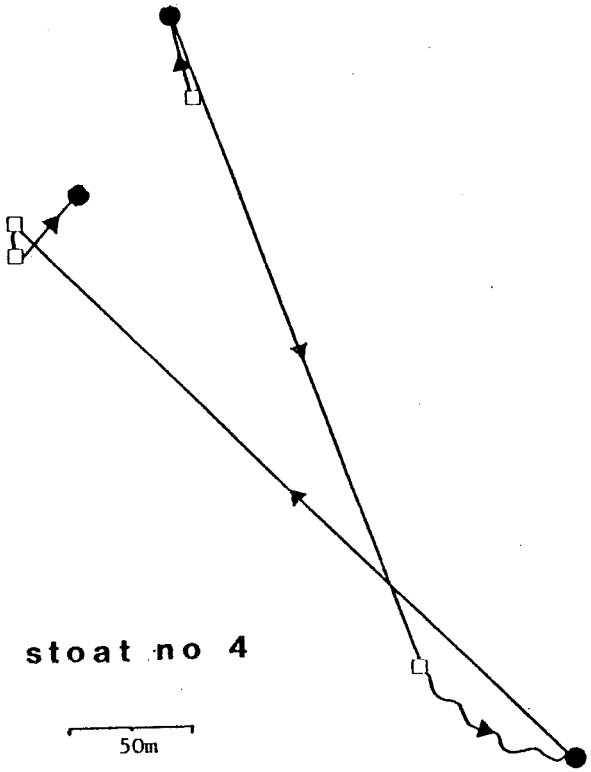
JUNE 23-30th

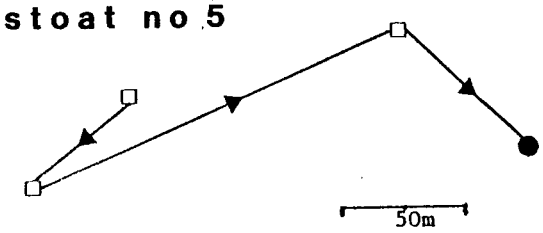


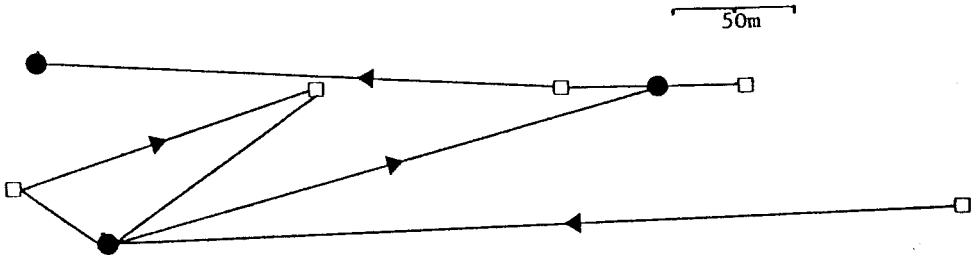
JULY 1-14th

Figure 25. Representative movements by stoat no 3 (Sally as revealed by radio location

Sequence of movements indicated by arrows.
Daily movement distances indicated by straight lines
Small-scale movements (type a) indicated by wiggly lines
Detected dens : ● Static locations : □







stoat no 6

Figure 26. Movements by stoats no.s 4, 5 and 6 -symbols as in Fig. 25.

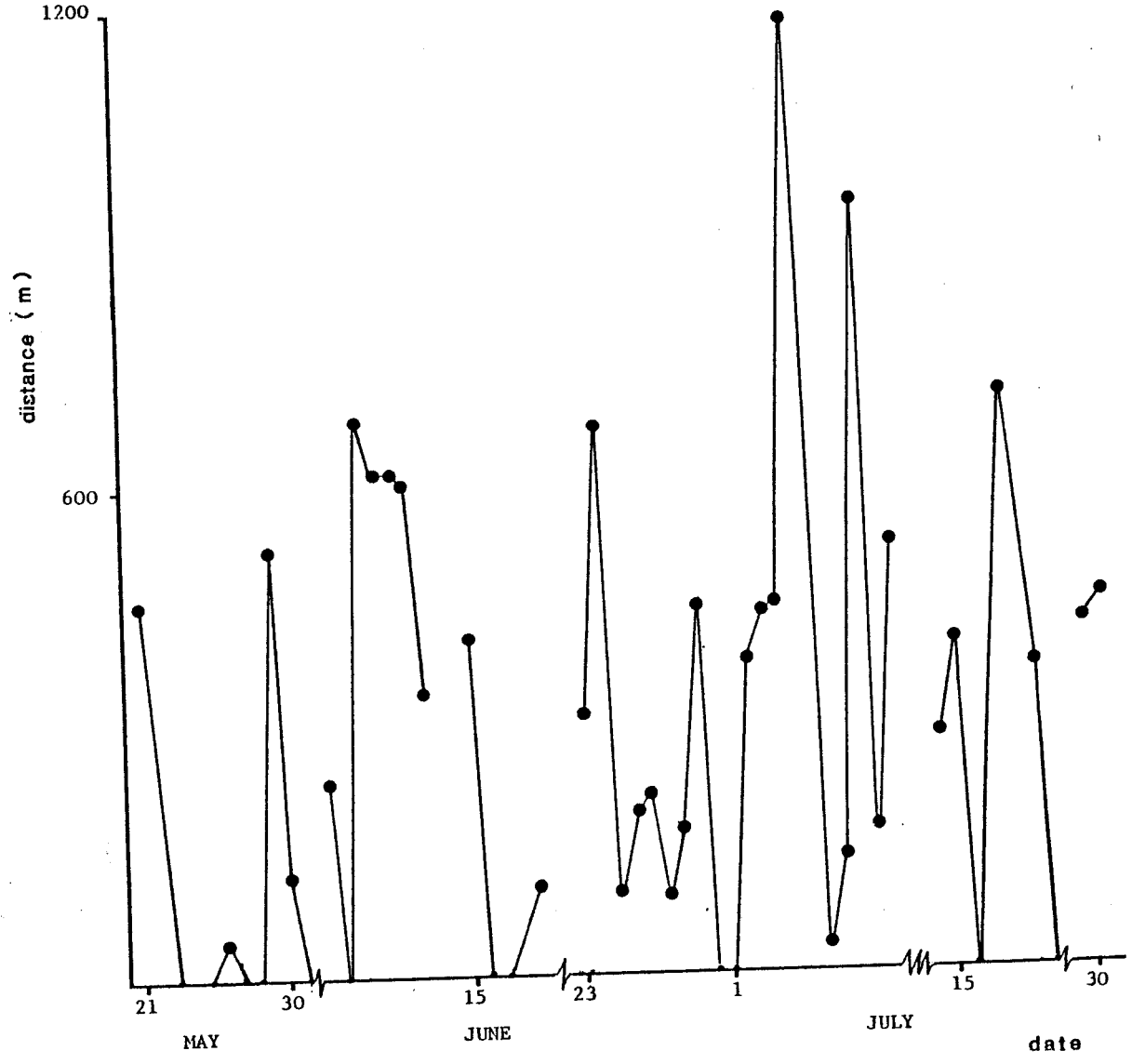


Figure 27. Daily Movement Distances by stoat no 3 (Sally) in May, June and July 1985.

3.2.8 Summary

The Irish stoat is known to be widespread, yet there is little previous information on either its habitat preferences or spatial distribution. The analysis of 525 records from various sources showed that stoats were commonly found in wooded and open country and less commonly in urban/suburban areas or on the sea-shore.

Trapping stoats proved difficult, and the spatial distribution of only a small number of stoats was investigated. Nevertheless, the method of investigation (radio-tracking) provided information not only on spatial distribution but also on habitat preferences and behaviour. The radio-tracking confirmed that stoats had a marked preference for woodland, and that they climb trees. It is well known that Irish stoats climb well and are often found up trees (e.g. Moffat 1890,1926; Bull 1894; Irwin 1896; C.Owen-pers.comm.; P.Smiddy-pers.comm.). They also showed a preference for areas of the trees where there were epiphytes. This has previously been noted by Matthews (1982).

The radio-tracking also showed that rat holes commonly provided den sites. The frequency of rat fleas on stoats (3.4.2) is without doubt associated with this.

Movements indicated territoriality and uneven use of home range area, with the animal visiting part of the home range for a few days and moving on (Fig.21). Eventually over about a week the animal would cover the home range. Movements from this study are compared with data from elswhere (Section 4.2.1.)

The home range size in one female, Sally, appeared to be larger than that of the rest of the stoats, a male and two other females. However as Sally's was the only home range considered complete this is not surprising.

3.3 FOOD HABITS

The food consumed by stoats was investigated by direct observation and by identification of prey remains found in guts and scats (faeces). There are few direct observations here, but since mammal predation is seldom witnessed firsthand, these are considered worth recording.

3.3.1 Direct Observations

The direct observations were obtained from radio-assisted -surveillance (2.2.4), sighting records and a road casualty. There was an observation of a tagged female stoat (No2) eating caged birds in May (2.2.3). A radio-tagged female (No3) was seen raiding birds nests in June and July. These nests belonged to a dunnock [Prunella modularis L.], wren, [Troglodytes troglodytes (Koch)] and a wood pigeon, [Columba palumbus L.]. There were also observations of stoats carrying prey from sighting records; single mice (Apodemus or Mus) in February and April 1984 (Appendix 12:A). In addition, one of the female road casualties was killed carrying a naked nestling rabbit (wt 47g) in March 1985.

3.3.2 Prey remains from guts

Guts were available from 138 of the 196 stoat carcases collected throughout Ireland. Of these, 89 (65%) contained recognisable prey remains. Most guts contained only one prey species, as has been found by other investigators (e.g. Aldous & Manweiler 1942; Day 1968). Only three guts were found with two prey species present: shrews figured in all three, being detected along with rabbit and two different birds. A total of 92 prey items were identified from guts. The stoats in which prey remains were found were predominantly from farmland and woodland (Table 24). Most (77) were road casualties, seven were trapped and eight died from 'other' causes (Appendix 8:A).

Male stoats predominated (63% of the sample see Table 23). Rabbit is clearly the most important prey detected, both in terms of frequency of occurrence and, even more so, in terms of biomass. Rats are also an important component. Shrews are frequent, occurring more commonly than birds, but less important in terms of biomass (Table 22). On two occasions shrew jaws, identifiable by their characteristic red-enamelled teeth, were recorded along with shrew hairs.

TABLE 22 FREQUENCY, PERCENTAGE FREQUENCY AND ESTIMATED BIOMASS VALUE OF PREY ITEMS IDENTIFIED FROM STOAT GUTS

Prey	Number of occurrences	% frequency of occurrence	Biomass weight (g)	% of Biomass
Rabbit	29	31.5	580	47.2
Rat	13	14.1	260	21.2
Birds*	17	18.5	170	13.8
Woodmouse	5	5.5	50	4.1
Vole	3	3.3	30	2.4
Shrew	24	26.0	120	9.7
Stoat	1	1.1	20	1.6
Totals	92	100%	1230	100%

* for further identification see text

The 16 occurrences of bird feathers were further identified to order where possible: nine were Passeriformes (perching birds), four Columbiformes (pigeons and doves) and three Charadiformes (waders,gulls etc.). Ensheathed feathers, indicating a moulting or nestling bird, were found on four occasions: Passeriformes two; Columbiformes one and one unidentified . Stones were found in seven guts, usually in small numbers. Such small stones have been reported in studies of stoat diet elsewhere (e.g. Taylor & Tilley 1984). On one occasion 72 such stones weighing 1.09g(dry) were found in a gut (Plate 2:C). It is considered likely that at least some of these stones were from the gizzards of birds.

As in other studies of stoat food habits (e.g. King & Moody 1982b) there was no significant detectable variation in prey types with age of stoats. This may be due to the small sample size, and the fact that adults and young were only differentiated for part of the year (3.1.3). Different ages are not therefore separated in the calculations.

The sexes however do have different diets ($p < 0.05$) females eating more small prey such as shrews and mice (Table 23). The seasons are defined here by three month periods: spring (March-May), summer (June-August), autumn (September-November) and winter (December-February), as used elsewhere in this study (3.4.2). Where

date of death and sex of the stoat are known, distribution of the prey of eash sex over the seasons are shown on Table 24. The sample size for winter months (4 prey items) is however too low for any comparison being presented nevertheless for the sake of completeness.

Percentage of prey taken varied significantly between the other three seasons (Table 24). Rabbits were most prominent in the spring. Rats were important in the diet of males in the autumn. Birds were most common in the diet of males in summer and that of females in autumn. Finally, shrews were clearly particularly important in the summer diet of female stoats and to a lesser extent in the diet of both sexes in the autumn.

One instance in which an intact stoat had tufts of stoat hair still attached to flesh in its gut, was considered to be an example of cannibalism. Such behaviour has previously been reported from captive stoats in Britain and wild stoats in New Zealand (East & Lockie 1965; King & Moody 1982b). The single occurrence of cannibalism in the spring suggests predation on young of the year, which would be in the nests at this time. Such behaviour has been noted in nests of captive stoats (East & Lockie 1965).

TABLE 23 FREQUENCY AND PERCENTAGE FREQUENCY OF OCCURRENCE OF PREY IN EACH SEX OF STOAT

	STOATS						
	Males n=58		Females n=34		Difference in percentages		
PREY	f	%	f	%	di	Rank	
Rabbit	21	36.5	8	23.5	13.0	+6	
Rat	9	15.7	4	11.7	4.0	+4	At n = 7
Bird	13	22.5	4	11.7	10.8	+5	and T = 8
Woodmice	3	5.3	2	6.0	.7	-2	reject null
Vole	2	3.6	1	3.0	.5	-1	hypothesis
Shrew	9	14.5	15	44.1	29.6	-7	at p < .05
Stoat	1	1.9	0	0.0	1.0	+3	
	58	100%	34	100%			

Tested using a Wilcoxan signed-ranks matched-pairs test.

TABLE 24 FREQUENCY (f) AND PERCENTAGE FREQUENCY OF OCCURRENCE (%) OF PREY IN 89 STOAT GUTS DISTRIBUTED BY SEASON AND SEX

	SPRING March-May				SUMMER June-August				AUTUMN Sept'-Nov'				WINTER Dec'-Feb'				Differences between seasons: χ^2 with 3 df	
	Females		Males		Females		Males		Females		Males		Females		Males		Males	Females
	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%		
Rabbit	3	43	14	57	4	30	4	22	1	10	3	30	0	/	0	/	34.3*	28.6*
Rat	1	14	4	16	2	14	2	11	1	10	3	30	0	/	0	/	4.3**	54.8*
Bird	1	14	1	4	0	/	7	39	2	20	1	5	1	50	2	100	23.3*	51.1*
Woodmice	1	14	1	4	1	7	1	5	0	/	1	5	0	/	0	/	20.4*	1.3***
Shrew	1	14	2	8	8	57	3	17	5	50	3	30	1	50	0	/	25.4*	22.3*
Vole	0	/	1	4	0	/	1	5	1	10	0	/	0	/	0	/	not sufficent data	
Stoat	0	/	1	4	0	/	0	/	0	/	0	/	0	/	0	/	not sufficent data	
Totals	7		24		15		18		10		11		2		2			

* $p > 0.001$

** $.50 > p > .20$

*** $.80 > p > .50$

The habitat of 65 stoats with identifiable prey remains in their guts was also noted. These data illustrate the habitat preference of the various prey. For example the voles, being bank voles [Clethrionomys glareolus] would be expected to occur most commonly in woodland (Flowerdew 1977) and rats would be expected to occur in farmland and urban situations, and indeed these habitats are where the stoats which had their remains in their guts were found (Table 25). Bird remains, as might be expected, were most commonly found in stoats from woodland, followed by open country and seashore respectively. Shrews were found in equal numbers of stoats from open and wooded country, as were rabbits. Rabbits are not usually considered woodland animals, however woodland margin provides good rabbit harbourage.

Most of the stoats (82%) from which prey remains were identified were road casualties. The surrounding habitat influenced stoat diet (Table 25), and the immediate roadside habitat may also have influenced this sample of diet. Rats are common on Irish roadsides. They were the commonest casualty recorded in the year-long road casualty survey on Irish roads (Sleeman, Smiddy & Sweeney 1985). Similarly, shrews are common in the mixed long grass and scrub vegetation typical of Irish roadsides.

TABLE 25 PREY FOUND IN STOATS FROM VARIOUS HABITATS

HABITAT	PREY Rabbit	Rat	Wood mice	Vole	Shrew	Bird	TOTALS
Open Country	10	5	2	0	8	3	28
Wooded Country	10	0	1	2	8	5	26
Suburban/urban	0	2	0	0	2	0	4
Seashore	0	0	1	0	0	2	3
TOTALS	20	7	4	2	18	10	61

TABLE 26 PREY FOUND IN STOATS FROM VOLE AND NON-VOLE AREAS

STOATS	PREY Rabbit	Rat	Woodmouse	Vole	Shrew	Bird
Non-vole area n= 49 (31 ♂♂ & 18 ♀♀)	14	9	5	/	11*	11*
Vole area n= 33 (20 ♂♂ & 13 ♀♀)	12	4	0	3	10	4

* shrew and bird remains recorded in same gut

It might be expected, due to regional differences in stoat size, that there would be significant geographic variation in food habits. However none emerged from this study as sample sizes from outside Co Cork were too small for statistical comparison. However when prey found in vole and non-vole areas were tabulated (Table 26), differences are evident between stoat diet in the two areas. Stoats from vole areas contained fewer rats, no wood mice, and fewer birds. Because diet is influenced by many factors a larger sample would be necessary to confirm this statistically.

3.3.5 Summary

Previous systematic work on food habits of Irish stoats has consisted of two investigations. Day (1968) analysed an unspecified number of guts of Irish stoats, along with those of British stoats and weasels. He failed to differentiate between stoats from Ireland and Britain, therefore his work is of limited use here. Fairley (1971) identified prey remains in 29 guts and some scats. These stoats were mainly killed by Ulster gamekeepers in March, April and May. Ten (34%) of them contained Lagomorphs [probably rabbits], and 13 (37%) contained birds. Less important were mice: Mus and Apodemus (17%) and rats (3%).

The data from this study also shows that rabbits are the most important prey species. The number of bird remains found by Fairley was higher than that found in this study. This is possibly due to the habitats that his stoats came from, where abundant game bird prey would have been available.

Various observers have made direct observations of individual items of the Irish stoat diet including; birds, mice, rats, rabbits, hares, fish and a frog (Derg 1887; Moffat 1890; Pentland 1917; Patterson 1926; Clowes 1933; Teacher & Gough 1936; Pack-Beresford 1936; Fairley 1975; 1985; Devane 1984). The prey listed suggest

that the Irish stoat is an opportunistic predator of suitably sized live vertebrate prey. Moffat (1938) suggested that, because of the smaller size of the Irish stoat, rats would "....form a larger proportion of its prey than is the case with the British species." The results of this study suggest that he was correct.

The direct observations in this study show that two Irish stoats observed raided the nests of birds and rabbits. Such nest raiding has been previously recorded (Fairley 1984). Records of naked, or near naked, rabbit nestlings are of interest as they would not be detected by gut analysis techniques based on hair identification. The role of rabbits in stoat diet during times when such young are in nests may well be underestimated. Small mammal prey, which here include rats, mice, voles and shrews, formed a greater percentage by number (48.9%) than rabbits, but they proved less so in terms of biomass (Table 22). The diet varied between sexes, seasons and habitats (Tables 23,24 & 25) based on limited data.

Shrews have been infrequent in the detected diets of Irish mammalian carnivores (e.g. Fairley 1970, 1980; Warner & O'Sullivan 1982; Robertson 1986). Nevertheless in western Irish bogland, a habitat where other prey is scarce, Forbes and Lance (1976) found that 15% of fox scats contained shrew remains. The frequency of shrews in the diet of the Irish stoat suggests that stoats often

eat this small and reportedly non-favoured prey (see 4.2.2) probably because of shortages of alternative prey. It is of interest that consumption of shrews is most pronounced in female stoats in summer and autumn (Table 24 & 3.3.4) which suggests that this is a time of particular shrew availability and/or prey scarcity for female stoats.

It has been suggested that shrews exist in Ireland at higher population densities due to the absence of other competing shrew species (Moffat 1938; Crowcroft 1957; Grainger & Fairley 1978). However, evidence for this is lacking (Ellenbrock 1980). Similarly, rats are postulated to be more common in Ireland, due to greater availability of cover (Fairley 1970) or density compensation due to the absence of voles. Certainly they are frequently encountered during studies of carnivore diets here (e.g. Fairley 1980).

3.4 PARASITES

Ectoparasites came from two sources: from live-trapped stoats at Fota (2.2.2) and from carcases examined in the laboratory (2.1.5). One endoparasitic nematode was studied indirectly by examining the damage it causes to the skull (3.4.3).

3.4.1 Ectoparasites from live-trapped stoats

Fleas were the only ectoparasites recovered from live trapped stoats. Two of the five such stoats had fleas. A female (Sally), trapped in May was infested by one rodent flea, Ctenopthalmus nobilis (Rothschild) and another female, No 4, trapped in August was infested by another seven Ctenophthalmus nobilis (2 males and 5 females). The latter group of fleas was recovered from the trap bedding, and not from the stoat itself. This is likely to be due to the agitation caused to the stoat by capture, as fleas are known to rapidly abandon agitated hosts (Stark & Kinny 1962).

3.4.2 Ectoparasites from stoat carcases

The examined 122 carcases which were considered fresh enough to be likely to still be infested by ectoparasites yielded 2,622 specimens. Despite the fact that many ectoparsites had undoubtedly abandoned these hosts, the species of ectoparasites are nevertheless of interest, particulary as they provide clues to habitat utilisation by their hosts. The most numerous specimens found were mites (Acarina; Acari) followed by lice (Insecta; Anoplura and Mallophaga); ticks (Acarina; Ixodidae) and fleas (Insecta; Siphonaptera).

The mites, despite being the most numerous specimens, were found on only 19 hosts and were therefore less widely distributed than lice, fleas and ticks (Table 27). Some mites are likely to have been free living species rather than ectoparasites and, except in one instance, they were not identified. The single mite species identified was Neotrombicula autumnalis (Shaw), commonly called the harvest mite. The adult mites of this species live in soil, only the larvae are parasitic on vertebrates. A female stoat killed in September was found to be infested by 1,819 larvae of this mite. Therefore Neotrombicula autumnalis was the most abundant species found, due to this single large infestation which represents 95% of the mites recovered. The larvae have been reported to be

TABLE 27 NUMBERS OF MITES, LICE, TICKS AND FLEAS FOUND ON 122 STOATS

	Mites	Lice	Ticks	Fleas
Total number recovered	1861	384	331	49
Number of hosts infested	19	57	23	26
% of hosts infested	15	46	18	21
Range of infestation	1-1,819	1-27	1-266	1-8

commonest in September on bank voles (Elton & Keay 1936). The numbers of these mites vary considerably over time, both within and between years. There are previous records from stoats in Britain (Richards 1950).

The majority of the lice (99%) were Trichodectes ermineae (Hopkins), which is specific to stoats and has been recorded elsewhere in Europe and North America (Hopkins 1960). This was the second most abundant species found, and the most widely distributed (Table 27).

Males carried more of these lice than females in all seasons where data was available. There were insufficent data on female infestations in winter (1 specimen). The percentage infestations for each sex are significantly different in all the seasons for which data were available ($\chi^2 = 131.5$, $p > 0.001$).

Seasonal differences in the percentage infestation by Trichodectes ermineae of both sexes were also examined (Table 28). Both female ($\chi^2 = 17.6$ $p > 0.001$) and male ($\chi^2 = 43.1$ $p > 0.001$) stoats had significantly different percentage louse infestations in the three seasons tested.

TABLE 28 PERCENTAGE OF STOATS INFESTED AND MEAN INFESTATION OF STOAT LICE, TRICHODECTES ERMINEAE FOR THREE MONTH SEASONS

		SEASONS			
STOATS		SPRING March - May	SUMMER June-August	AUTUMN Sept.- Nov.	WINTER Dec.-Feb.
MALES	N	40	18	13	10
	%	55.8	71.5	38.0	12.5
	Mean(x) (+SEx)	5.7 (0.197)	3.5 (0.238)	2.0 (0.281)	0.62 (0.150)
FEMALES	N	4	16	11	1
	%	16.6	43.7	18.2	insufficent data
	Mean(x) (+SEx)	0.16 (0.062)	1.43 (0.140)	1.09 (0.224)	

For both sexes the highest percentage infestation was in summer (June-August) This is likely to be due to breeding activities. However, the highest mean infestation rate was recorded from adult males in spring, a time when males are reported to increase their home range (Erlinge 1981).

As with mites, louse infestations were highly clumped the majority of hosts having seemingly no lice. This is likely to be more apparent than real given the limitations of the sampling technique (see 2.1.5).

The stoat lice came from every county sampled, with the exception of Derry. Two lice not specific to stoats were recovered; a rat sucking louse, Polyplax spinulosa Burmeister and a bird- [corvid] biting louse Mysidea picae Handeln (identified by W.Eichler). These species are regarded as accidental and were presumably acquired by stoats during intimate contact with prey species [rats and corvids]. The occurrence of lice, which are noted for their host specificity, from prey species on mammalian carnivores has been recorded by other workers (e.g. Whitaker & Goff 1979; Haitlinger 1980).

Three species of tick were recovered; Ixodes hexagonus Leach, Ixodes ricinus (L.) and Ixodes canisuga Johnson (Table 29).

Ixodes hexagonus was the most frequently recovered and most widely distributed tick. All three stages of its life cycle (larvae, nymphs and adults) were found. Ixodes ricinus and Ixodes canisuga were uncommon, only larvae of the former species and a nymph of the latter species being recovered.

Ixodes hexagonus is a nest tick (Arthur 1963). It was found in all months of the year except February, July and December. No seasonal trends in distribution on hosts and no preference by the parasite for any particular group of hosts were detected. This may be due to the relatively small sample available. One infestation was however unusally large. A female stoat was found to be infested by 266 larvae of this tick in November. Such heavy infestations have been detected in other studies, for example the 380 nymphs and larvae found on an urban fox reported by Harris and Thompson (1978). This reflects the clumped distribution of Ixodes hexagonus on stoats, (i.e. variance devided by the mean less than 1) which is similar to the apparent distribution of the mites and lice. A similar to the pattern of tick distribution on mammalian hosts has been found by other investigators (e.g. Randolph 1975; Harris & Thompson 1978)(see Appendix 6:A).

Ixodes hexagonus was found on stoats from nine counties showing it to be widely distributed. It has previously been recorded in Ireland from hedgehog, otter, cat and mink (Fairley 1980 and

TABLE 29 NUMBER, PERCENTAGE INFESTATION AND SEX AND/OR STAGE(S) OF TICKS AND FLEAS FROM STOATS

PARASITES	Number recovered	% stoats infested	Sex and/or stage(s) of the parasite
TICKS			
Ixodes hexagonus	318	14.0	291 larvae, 23 nymphs and 4 adult females
Ixodes ricinus	12	4.0	12 larvae
Ixodes canisuga	2	1.6	1 adult female & a nymph
FLEAS			
Ctenophthalmus nobilis	28	12.3	11 males, 15 females 2 unsexed due to damage
Nosopsyllus fasciatus	17	7.4	3 males, 14 females
Dasypsyllus gallinulae	3	2.4	2 males, 1 female
Spilopsyllus cuniculi	1	.8	1 female.

unpublished Irish records). In Britain it has been found on stoats, hedgehog, weasel, polecat, otter, badger, cat and fox (Arthur 1963; Walton & Page 1970).

Larvae of Ixodes ricinus were found on stoats in May, June, August and October. These are months when larvae of this tick tend to be active in Ireland (Walton & O'Donnell 1969; Gray 1980). Ixodes ricinus, the pature tick is very common and widely distributed in Ireland, particularly on rough pasture. It has been recorded from a very wide variety of hosts in Ireland (Walton & O'Donnell 1969; Sleeman 1983; Fairley 1984). Of particular interest is its occurrence on the common rat (Walton 1965; Appendix 6:C). It has also been reported from a wide variety of hosts in Britain (Arthur 1963). Ixodes canisuga was recorded twice from stoats in this study. It is regarded as rare in Ireland. In Britain it has been recorded from dog, polecat, and fox (Arthur 1963; Walton & Page 1970; Harris & Thompson 1978).

Four species of flea were recovered: two were rodent fleas; Ctenophthalmus nobilis (Rothschild) and Nosopsyllus fasciatus (Bosc); one bird flea, Dasypsyllus gallinulae (Dale) and one rabbit flea Spilopsyllus cuniculi Dale (Table 29). There are too few flea records to realistically interpret seasonality on the stoats. However, it is evident that significantly more of the

rodent fleas were found on stoats in June than in any other month. Fifteen Ctenophthalmus nobilis (53.5%) were recovered in June and eight Nosopsyllus fasciatus (46.4%) were recovered in this month. The remainder of the rodent flea records were scattered over the months of February to August, October and November.

The bird flea, Dasypsyllus gallinulae was found in April and May. As this flea is characteristic of bird nests built in low positions (Smit 1957) and these months are during the nesting season, this is not unexpected and presumably results from stoats visiting, and probably denning in, bird nests. The single rabbit flea Spilopsyllus cuniculi was recovered in March. The locations and dates of each flea record are listed in Sleeman (1987)(see Appendix 6:B). As with ticks, there are insufficent numbers of fleas to warrant an analysis of frequency distribution of each species. Thus the numbers of all flea species were pooled. The distribution of fleas (Appendix 6:A) is clumped as has been found by others working on non-specific fleas on carnivores (e.g. King 1976; Mardon & Moors 1977; Buckle & Harris 1980; King & Moody 1982g).

3.5.3 Endoparasite : Skrjabingylus nasicola (Leuckart)

The only endoparasite investigated was the nematode Skrjabingylus nasicola. The presence of this parasite is easily detected indirectly due to the damage it causes to the skull (Plate 4). Other endoparasites were not investigated.

To confirm the presence of Skrjabingylus nasicola in Ireland, a stoat whose skull had been broken by a traffic accident, but showed the damage characteristic of this parasite (2.1.5), was dissected. The position of these parasites in the frontal sinuses makes removal of the specimens without destroying the skull impossible. The stoat yielded five worms, a male and four females. These were mounted and compared with the Skrjabingylus nasicola illustrated in Soet, Land & Bree (1972). A pair was then sent to the British Museum (N.H.) where their identity was confirmed by D.I.Gibson.

A total of 36 intact skulls from Ireland were examined. Of these, 18 (50%) showed such damage, often on both sides of the skull. Skulls of female were more frequently damaged than were those of males; eight out of nine female skulls (88%) being damaged whereas only 10 out of 27 male skulls (37%) were affected. Assuming that such damage should be equally distributed between the sexes, these percentage infestations are highly significantly different ($\chi^2 = 20.8$, $p > .001$). It is possible that stoats suffering such

damage might be more prone to become road casualties. However the data available does not support this idea. Only 12% of the skulls of stoats killed in road traffic accidents showed damage whereas 21% of those killed by other causes showed damage.

The skulls of both adults and young showed such damage, the young showing damage at as early as an estimated age of 2 months. Damaged skulls came from seven counties and were therefore widely distributed. The skulls of four mink, two pine martens, two otters and a badger from Ireland were also examined for such damage (Appendix 6:D) but none was found.

3.4.4 Summary

The harvest mite, Neotrombicula autumnalis, has not previously been recorded from stoats in Ireland, but three other species of mite have; i.e. Eulaelaps stabularis (Koch); Euryparasitus emarginatus (Koch) and Haemogamasus nidi Michael (Fairley 1971). There is a previous published Irish record of the louse Trichodectes ermineae from stoats (O'Mahony 1946), but none for the three tick species recovered in this study. The four species of fleas found have all previously been recorded from stoats in Ireland (Claassens & O'Rourke 1966; Fairley 1971; Fairley & Foster 1979).

There were more lice on males than on females in all seasons for which data were available. This could be because males may generally groom less than females. There are marked increases in the level of detected louse infestations in both sexes in summer, and in males in the spring (Table 28). It is considered likely that these reflect seasonal patterns of activity. Normally a solitary mammal, the stoat is involved in breeding activities in summer, and it is possible that this prevents them from grooming as much as at other times of year. This possibility and the greater opportunities for successful transfer for the louse during this time could be responsible for the apparently higher infestation

rates at this time of year. Increased activity during the spring expanding their home range (Erlinge 1977b) and this may be linked to the high infestation rate in males recorded in that season.

The absence of well defined seasonality in the occurrence of the tick Ixodes hexagonus is probably a reflection of the fact that this is a nest tick, and as Arthur (1963) points out, the occurrence of this parasite on the host probably gives a false picture of the tick's ground activity. The stoat is considered to be a primary host of Ixodes hexagonus. In contrast there were few Ixodes ricinus, yet it is regarded as common in Ireland (e.g. Sleeman 1983). The Ixodes ricinus recovered were clearly seasonal and reflect the known periods of larval activity.

None of the fleas recovered is specific to stoats. Stoats in more northerly areas have specific fleas, as is the case in weasels (King 1976). For example, Ceratophyllus lunatus Jordan & Rothschild is a northern Scandinavian stoat flea (Smit 1969) . However, in temperate countries such as Ireland these fleas are not present, possibly due to the absence of permanent nests. Fleas are primarily nest parasites (Smit 1957). Ctenophthalmus nobilis, having as its primary hosts wood mouse, the common rat and vole, is the most abundant Irish rodent flea. The common rat is a primary

TABLE 30. THE STOATS' FLEAS, THE USUAL HOSTS OF THE FLEAS AND THE ROLE OF THE USUAL HOSTS IN STOAT DIET AND HABITAT

Flea	Number of stoats infested	% of total fleas	Usual Hosts	Usual host as % of stoat prey	% use of usual hosts habitat by stoats*
Ctenophthalmus nobilis	15	57.1	Woodmouse (also rat & vole)	5.5	5
Nosopsyllus fasciatus	8	34.7	Common rat	14.1	53
Spilopsyllus cuniculi	1	2.1	Rabbit	31.5	23
Dasypsyllus gallinulae	2	6.1	Bird	18.5	19

* data reworked from Tables 17,18 & 19 omitting unidentified underground habitats and including all arboreal records as bird habitat.

host for both Ctenophthalmus nobilis and Nosopsyllus fasciatus, while the rabbit is the primary host for Spilopsyllus cuniculi and birds are primary hosts of Dasysyllus gallinulae (Claassens & O'Rourke 1966; Sleeman & Kelly 1987 see Appendix 6:C).

The high percentage of rodent fleas (91.8%) does not accurately reflect the role of rodents in the stoat diet (19.6%) (see Table 31). Similarly, the one record of a rabbit flea does not reflect the important role of the rabbit in the stoat diet. The occurrence of these fleas is not therefore, as has sometimes been suggested by other workers (e.g. Fairley 1971), related to what they eat. The occurrence of these fleas does however broadly reflect the use of the host's usual habitat by stoats, in particular rats' nests (Table 18 & 19). This indicates that stoats acquire fleas from the habitat they visit, in particular nests, rather than directly from their prey (see Table 30). The same conclusion has been reached in other studies of fleas from stoats (Debrot & Mermod 1982; King & Moody 1982g) and weasels (King 1976; Mardon & Moors 1977).

It is of interest that no fleas specific to shrews were recovered despite the fact that shrews occurred in 26% of the guts examined (Table 22). Shrews figured frequently in the diet of the females in summer (Table 24) when there were adequate numbers of females to examine (Table 4). Two species of recognised shrew-specific fleas are known from Ireland: Doratopsylla dasycnema (Rothschild) and

Palaeopsylla soricis (Dale) which have been found widely distributed (e.g. Grainger & Fairley 1978; Sleeman 1979). The absence of shrew fleas from stoats suggests therefore that stoats do not frequently utilise shrew nesting areas (see 4.1.1) and supports the theory that stoats do not acquire fleas directly from their prey. The shrews eaten are presumably captured away from their nests.

Given the similarity between the flea fauna of rats and stoats in Ireland it is surprising that the prominent tick on stoats is Ixodes hexagonus whereas the prominent tick on rats is Ixodes ricinus (Walton 1965; Appendix 6:B). This may be due to the avoidance of open ground by stoats (Tables 15,16 & 17) which would include pasture, one of the favoured habitats of Ixodes ricinus in Ireland. The usually rapid speed at which stoats travel over open ground, (3.2.7) may also be a factor in their relative freedom from Ixodes ricinus. Alternatively it is possible that they are, in some way resistant to Ixodes ricinus. The ectoparasites had a predominantly overdispersed distribution on their hosts. hosts, which is in keeping with the predictions of Crofton (1971).

The single endoparasite recorded, Skrjabingylus nasicola, has previously been recorded from stoats in Ireland by Montmorency (1935). Significantly more damage by this parasite occurred on female stoat skulls.

Section 4

THE ECOLOGY OF THE IRISH STOAT:

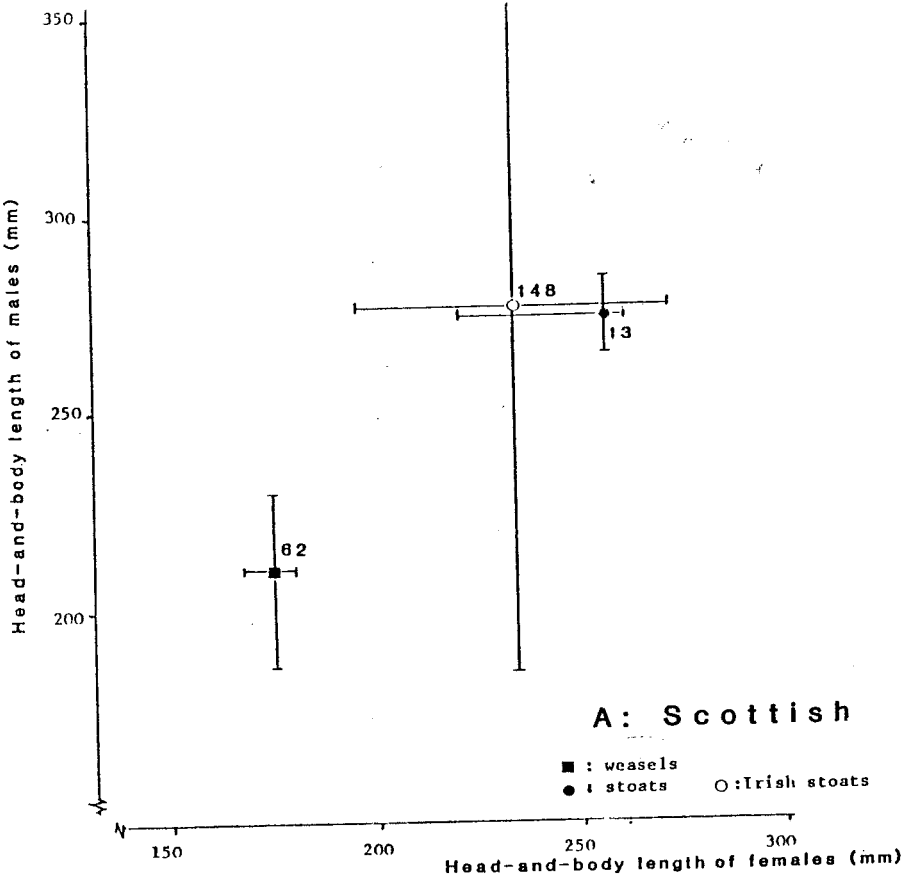
A COMPARATIVE DISCUSSION

4.1 FORM

4.1.1 Size

The occurrence of stoats and weasels together in the same habitat has puzzled ecologists (e.g. Aspisov & Popov 1940; Rosenzweig 1966; Powell & Zielinski 1983). They are, or appear to be, closely related animals with similar habits. It is regarded as axiomatic that they have competed and that their size difference is a consiquence of the avoidence of such competition (e.g. Lack 1947; King & Moors 1979). Hence the interest in areas such as Ireland, where stoats but no weasels are present.

The original describers of the Irish stoat claimed that it was smaller than British stoats (Thomas & Barrett-Hamilton 1895a). This is not always the case as the assertion is based on biased samples from northern Ireland and southern England (1.1). Using small samples of British stoats from England and Scotland (see 2.1.1; Table 32 and Appendix 5:C) the head-and-body lengths of males and females are compared with the Irish sample of 148 stoats (Fig.28). The mean measurements differ slightly, however it is clear that the range in size (represented by bars in Fig.28) of the Irish stoats in all cases overlaps that of British stoats, which is similar to Dadd's (1970) findings.



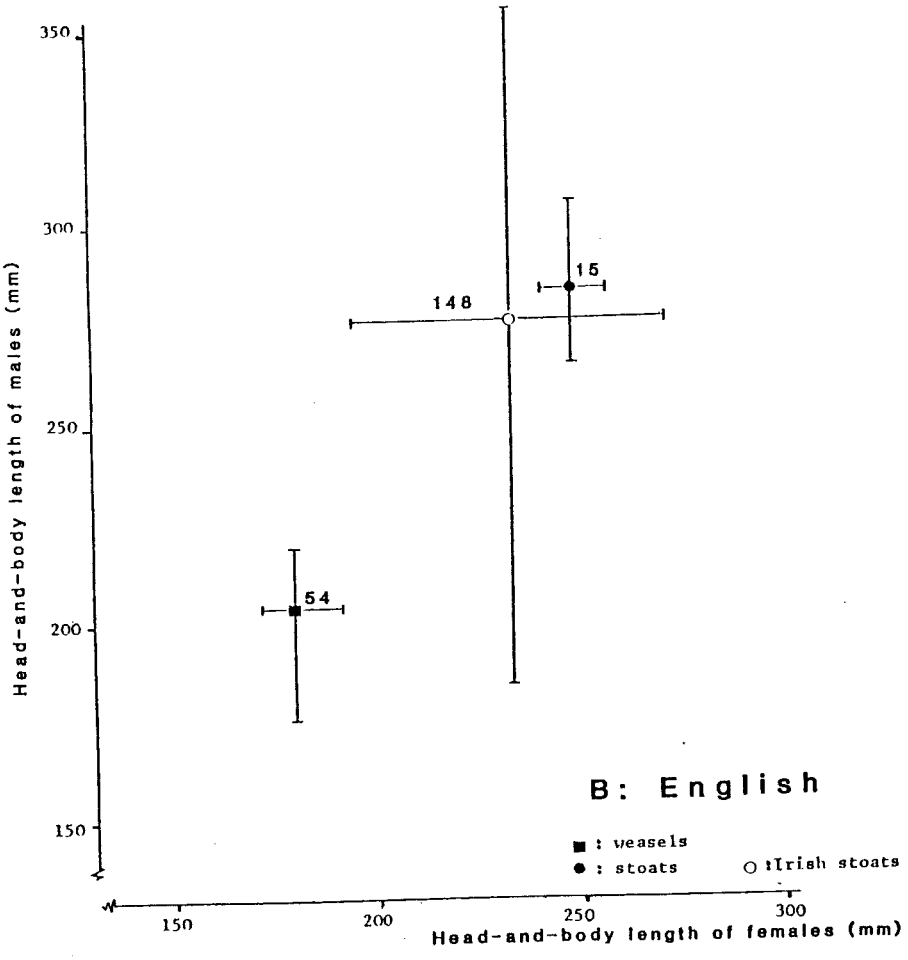


FIGURE 28. MEAN HEAD-AND-BODY LENGTHS (BARS REPRESENT RANGES) OF BRITISH STOATS AND WEASELS (A: SCOTTISH, B: ENGLISH) COMPARED TO THOSE OF IRISH STOATS - NUMBERS REPRESENT SAMPLE SIZE

The claim that the Irish stoat is intermediate in size between the British stoat and weasel and hence confirms their morphological character displacement (Hutchinson 1959; Williamson 1972) is clearly incorrect. The dimensions of southern Irish stoats are almost as great as, and sometimes greater than, those of the average British stoat (Fig.28). The hypothesis proposed by both Hutchinson and Williamson was also based on the earlier biased samples, hence the incorrect conclusions (see 1.1 and also Ralls & Harvey 1985). The absence [until recently] of voles from Ireland means that there was virtually no food component of a weasel niche here, and hence there was no reason relevant to the competitive release hypothesis why stoats should adapt by becoming smaller.

Similarly, the North American examples of supposed morphological character displacement in stoats and weasels put forward by McNab (1971) and more recently by King and Moors (1979) have recently been shown to be incorrect. In a detailed analysis, Ralls and Harvey (1985) found that stoats in North America increased in size with increasing latitude regardless of the presence or absence of either the longtail (Mustela frenata) or the weasel. Their data showed no evidence for character displacement. There has been in general, failure to find many valid examples of morphological character displacement (1.1). In a review Grant (1972) failed to find evidence to support many the traditional examples though he

did find good evidence for other forms of character displacement, notably behavioural and physiological.

When the sizes of stoats and weasels from two different parts of Britain are compared, Scottish stoats are relatively smaller and weasels relatively larger than those from England (Fig.28). Due to reduced biomass, [which should be reflected in reduced prey availability], and increased energy demands to maintain body temperature in the north (Scotland), competition between stoats and weasels should be greater in Scotland than in England. The evident size clines with stoats becoming smaller and weasels becoming larger northwards (see 1.1; Fig.28, also King 1977b) continue apparently unaffected by this supposed competition. Indeed these proposed clines make unlikely the hypothesis that the sizes of stoats and weasels in England are primarily influenced by competition.

The fact that stoats and martens both reproduce by delayed implantation whereas weasels and polecats do not stoats may share an ancestor with martens (Martes spp.) and weasels with polecats (e.g. King 1984b; McInerney 1986). If this is the case it would remove the difficulty in explaining why two closely related animals appear to have evolved.

If interspecific competition is not a major influence on stoat size, why is there such variation in size across the stoat's range ? To summarise such variation; stoats are smallest in North America where they become larger northwards . Small stoats are usual at high altitudes and in northern parts of Eurasia (e.g. Shubin & Shubin 1975). To date there has been little agreement as to what factors cause such variation in stoat size. In North America, size of stoats has been said to be determined by temperature and latitude (Rosenzweig 1966) or by competition and prey availability (McNab 1971; Simms 1979a). In Europe interspecific competition has been regarded as an important factor in determining size (Williamson 1972; Pontin 1982).

Stoat size can be divided into two elements: that of males and that of females. In stoats these elements differ substantially due to marked sexual dimorphism. Such sexual dimorphism is a common feature of all solitary mustelids and has led to two explanatory hypotheses. The first, put forward by Brown and Lasiewski (1972) sees dimorphism as resulting from selection favouring different food exploitation by males and females, making it possible for both sexes to share the same area. The second, developed independently by Sam Erlinge and P.J.Moors [the Erlinge-Moors hypothesis], sees dimorphism as an adaptation for different reproductive roles of males and females, and incorporates part of the Brown and Lasewski

hypothesis Stoats are polygynous and the males would be expected to be large because of sexual competition for females. The females, Erlinge and Moors argue, are small because this allows them to enter small prey burrows and small size also allows them to channel more energy into reproduction because of their own reduced needs within a small area (Moors 1974, 1980; Erlinge 1979).

The Brown and Lasiewski hypothesis has been critised by several authors (Erlinge 1979; Moors 1980; Ralls & Harvey 1985). As Moors (1980) put it: "avoidance of competition is not the primary advantage of dimorphism ".

The Erlinge-Moors hypothesis on the other hand, itself based on observations on stoats and weasels, has received support from North American studies of the fisher, Martes pennanti Erxleben (Powell 1979b; Powell & Leonard 1983). However, despite acceptance of the possible role of prey size in determining stoat size, Ralls and Harvey (1985) have argued that there is little evidence for this hypothesis except for proposed excessive energy expenditure of hypothetical male-sized females.

The Erlinge-Moors hypothesis is a general proposal that can attempt to account for the range in stoat size. For if the size of the

female in the breeding season is critical this will influence size of both male and female, as presumably there is some link between size of both sexes. The data on the diet of female Irish stoats in summer certainly suggests a possible prey shortage during breeding, evidenced by the increase in the numbers of shrews comsumed (Table 24). So too does the large size of the breeding female's home range in June and July (Table 14; Figs. 21 & 22). The high numbers of stoat lice on such breeding stoats (Table 28) may be related to a loss of condition due to increased activity.

Breeding female mammals are known to need considerable quantities of energy [66% - 140% more than non-breeding ingestion] and protein (e.g. Myrca, Ryskowski & Walhoura 1969; Miller 1978; Berry & Louw 1982). Captive female stoats with young show a marked increase in food consumption (Müller 1970; Erlinge 1979). Food requirements by breeding female stoats are high, leading to an increase in the food intake and quite probably also to food shortages. These facts do not necessarily mean that this will lead to selection for small body size in females during the breeding season. The question here is: does the Erlinge-Moors hypothesis agree with what we know about the Irish stoat ?

Sexual dimorphism in adult stoats appears to be greater in Ireland than in Britain or New Zealand (Table 31). This the result of the average Irish male stoat being larger, relative to the average

TABLE 31 SEXUAL DIMORPHISM OF VARIOUS SIZE MEASUREMENTS IN ADULT STOATS FROM IRELAND, BRITAIN AND NEW ZEALAND.

	Mean % size dimorphism	Range [see 3.1.4]	Source
Ireland*	14.5 %	11.7 - 18.3 %	This study
Britain	10.7 %	not available	King & Moody(1982e)
New Zealand	9.6 %	6.5 - 12.0 %	King & Moody(1982e)

* excluding tail measurements which were not used by King & Moody (1982e) and skull measurements (see 3.1.4)

Irish female, while the female is considerably smaller relative to its British and New Zealand equivalents (Table 32). Why is the female Irish stoat so much smaller? Can the Erlinge-Moors hypothesis account for this?

The Erlinge-Moors hypothesis claims that small females are selected for because this allows them access to small prey burrows, by which they presumably meant, principally, vole burrows, as voles are a major prey item. With the absence of voles in most of Ireland [and little evidence of frequent utilisation by stoats of those present], it could be argued that instead, female stoats are small enough to fit into wood mouse or shrew burrows. However, there is little evidence that they spend much time in wood mouse burrows (Table 18) or eat many of these mice (Table 22).

Shrews in Ireland, i.e. pygmy shrews Sorex minutus, do not make burrows themselves but they do utilise burrows made by other species. They will hide and nest in crevices and holes, so perhaps female stoats could be adapted to entering such shrew habitats. It is known that the fleas found on stoats come mainly from nests they occupy. If female stoats did enter shrew nesting areas frequently it would be expected that they would harbour some shrew fleas. Such shrew fleas are widely distributed in Ireland (3.4.4). Despite the many female stoat carcases examined during the summmer, when such

TABLE 32 HEAD-AND-BODY LENGTHS OF STOATS (MAINLY ADULTS) FROM VARIOUS AREAS (mm)

	Males			Females			
Area	Mean	Range	n	Mean	Range	n	Source
Ireland	283	242-355	70	237	195-268	34	This study
Isle of Man	262	232-290	3	226	223-232	4	This study
England [South]	284	265-306	13	249	241-257	2	This study
Scotland [Perthshire]	274	264-284	9	256	220-261	4	This study
France & Germany	258	235-280	5	240	240	2	Miller 1912
Switzerland [St Gallen]	271	251-292	8	226	218-242	3	Miller 1912
Soviet Union [Kamchatka]	237	200-280	89	199	186-215	29	Vershinin 1972
New Zealand	284	204-312	461	256	223-283	440	King & Moody 1982c
Canada	272	251-315	?	236	215-255	?	Banfield 1974

behaviour could be expected, no shrew fleas were found. It would appear therefore that either the small female Irish stoats are not selected to exploit small prey, or that shrew fleas do not transfer to stoats. If the former explanation is valid it does not support the Erlinge-Moors hypothesis.

In Ireland it is not apparent that the small females are selected to optimally exploit small prey, neither do they appear to be selected to rear young in a restricted area. Sally, the breeding female radio-tracked during this study, had a large home range (see above), presumably in order to have access to prey. Therefore another explanation of small size is needed.

In the nineteen-sixties two British investigators kept both stoats and weasels in captivity (East & Lockie 1964, 1965). Their observations of the growth of young are particularly relevant to any discussion of size in small mustelids. They found that the body weight of captive reared young weasels, provided with unlimited food, was much higher than that typical of the wild population. Wild females weighed around 60g, captive reared females 85g. The single captive male continued to gain weight after the females had stopped doing so at around 50 days old. This male went on to reach a weight of 300g at 100 days, in comparison to wild weasel weights of around 130g (East & Lockie 1964). Subsequent litters of stoats

and weasels confirmed this trend. Their stoats appeared to grow most rapidly at between 40 and 120 days old, which occurred in the months of May, June and July (East & Lockie 1965).

Other studies of captive stoats agree with the findings of East and Lockie. Müller (1970) in Switzerland showed maximum weight gain occurring for female stoats between approximately 20-90 days old and for male stoats between 20-130 days old. The food required by Müller's mother stoats with their young increased rapidly over the months of May, June, and July to a value of approximately 700g per day. Similarly, Segal (1975) working in Russia found that his female stoat attained the maximum increase in body weight at 70 days, while his male attained it at 80 days. Erlinge (1979) in Sweden observed that "a female with young caught four times as many prey per hunting time as did non-breeding females".

It has been argued (Ralls & Harvey 1985) therefore that stoat sexual dimorphism results from selection for early sexual maturity in females coupled with sexual selection in large males, and that the differences detected in diet of adult males and females are the result rather than a cause of the phenomenon. The fact that female stoats virtually stop growing [skeletally] at around 130 days suggests that they are rapidly developing for some end, quite probably for early sexual maturity and consequent fertilisation.

Young female stoats are sexually precocious and can be fertilised when they are approximately 35 days old (Müller 1970).

Within the hypothesis of sexual dimorphism caused by selection for early maturity in females and large size in males, the geographical variation in size of stoats could be accounted for by variation of local prey availability over the first 90 days of female stoats and 130 days of males. The additional time taken by males in reaching adult size allows them access to a wider variety of prey, presumably outside the nest. The longer growth period in males therefore allows for greater dimorphism to arise, particularly in populations living in sub-optimal [prey impoverished and/or cold environment with low productivity] areas, for example, in Ireland, or unfavourable areas of the Soviet Union (Shubin & Shubin 1975).

The relatively large size of stoats from parts of Ireland, Britain and New Zealand in comparison with stoats from mainland Europe, Russia and Canada could to be due to the rabbit being the main prey on each of these islands (see 4.2.2), whereas on the continental mainlands the main prey is generally voles, which would provide less biomass per unit capture than rabbits.

Similarly, the small size of stoats in certain areas of North America has been explained by the fact that the main stoat prey there is often Microtus pennsylvanicus (Ord), [a small vole] whereas the large Eurasian stoat [which weighs 2.5 times more than stoats from southern Ontario] feeds on the larger water vole Arvicola terrestris (L.)(Simms 1979a).

The north/south size cline which appears to occur in both Irish and British stoats as well as elsewhere (1.1), can also be explained in terms of prey availability. The further north one goes, the lower the input of energy from the sun. Therefore there is less productivity by plants per unit area. This is reflected both in the diminished diversity of life, from the tropics to the tundra, and diminished biomass in terrestrial ecosystems.

For stoats this means fewer prey in an environment where they must maintain higher metabolic rates. For example weasels are known to increase their basal metabolic rate by 2 to 3 times in the Arctic (see Iversen 1972). Danish experiments involving the breeding of house mice, Mus domesticus , at various temperatures have shown that those kept at low temperatures have reduced body size, probably due to the need to increase their metabolic rate (Knudsen 1962). In Ireland such differences between north and south at first do not appear very marked. However, it is evident that whereas the

grass- growing season in the south lasts almost all year round (February- December) in the north this period may be only 8 months long (mid-March to mid-November) (see Map 31 in Haughton, Andrews, Breathacht, Gardiner, Hughes, Kirk, Walsh & O'Regan 1979). This considerable difference in plant productivity is presumably reflected by prey densities, and by prey availability to stoats.

The reported north/south clines could be explained by the influence of low food availability and low temperatures requiring increased metabolic activity in colder northern areas. Similarly the modern stoats' immediate predecessor Mustela palermina Peténgi, which existed in the middle Pleistocene, was larger in the warmer interglacials (Kurtén 1968).

The size of other mammals is known to be determined by food availability, particularly in the first year of life. Body weight of badgers Meles meles (L.) in Britain is considered to be determined by food availability (Kruuk & Parish 1983). Growth of young foxes Vulpes vulpes L., was correlated with vole abundance in Sweden by Lindström (1983). However foxes appear to compensate for poor growth during a first year resulting from few voles by continued growth later in life. This does not appear to occur in stoats, possibly because they rarely live long enough. Other

examples of food availability affecting body size are known from whales (Balaenoptera spp.) (Brodie 1975), and wild deer in Britain. In Scotland, both fallow Dama dama (L.) and red Cervus elaphus L., are known to be smaller than such deer in England, and other more favourable habitats in Europe. This has been interpreted as being due to a lack of food early in life (Chapman & Chapman 1969; Blaxter, Kay, Sharman, Cunningham & Hamilton 1974). Suttie (1980) tested this theory by differential feeding of captive red deer and found that large or small deer could be produced by different feeding regimes. He concluded that the differences in size between subspecies of red deer were produced principally by the quantities of food available.

It has been known for a long time that human beings "....like all good mammals show a positive correlation between resource availability and body size" (Geist 1983). It is also known that human body size is determined mainly in the adolescent (Tanner 1962). In studies in North America it has been shown that immigrants into the area from Europe and Asia, with a subsequent improvement in "quality of life" [mainly improved food availability], produce offspring who are taller than they were, although today this phenomenon appears to have run its course (Stewart 1980). It is of interest that the underprivileged status of women in antiquity, with associated lack of food, is considered

to have contributed to the greater sexual size dimorphism that existed then (Manchester 1983, page 10).

One set of data in this study that appears not to support the hypothesis that size is determined by food/prey availibility is the lack of a difference between stoats from vole and non-vole areas (Table 12). Surely the presence of such a suitable prey species as the vole ought to provide sufficient prey biomass to allow for an increase in size?

However, the vole does not in fact figure prominently as a prey item of the Irish stoat (Table 22), and as is suggested later, this could be due to lack of accessibility (see 4.2.2.). It may be more worthwhile to look for behavioural rather than morphological differences in carnivores between vole and non-vole areas, given the short history of voles in Ireland.

Are other wild Irish mammalian carnivores different in size from their British equivalents? Three of the postglacial carnivores, the wolf, wild cat and bear are now extinct (Table 37), and with few remains available we will probably never ascertain their average sizes. The pine marten is now a rare animal with a restricted distribution, so its size would be difficult to ascertain. There are few published data available on badger size,

however regional collections of foxes, mink and otters provide some comparative data. Irish mink, which have a similar history to that of mink in Britain (Thompson 1977), appear to be a similar size to English mink, however female Irish mink are large compared to English mink (see data from Fairley 1980 & Chanin 1983 in Appendix 12:B). Irish otters appear to be the same size as British otters (see data from Stephans 1957 in King 1977d & Fairley 1972b in Appendix 12:B).

Mink and otter are aquatic or semi-aquatic, and they therefore draw on a different prey base from stoats. Nevertheless the sizes of British and Irish mink deserve further study. The fox appears to be the only Irish carnivore that merits our attention here. It is known that foxes from Northern Ireland and Scotland are larger than foxes from England (Kolb & Hewson 1974; Fairley & Bruton 1984). This appears therefore to be the reverse of what could be expected if food availability affects size. However there are important differences in behaviour between of foxes and stoats during the rearing of young. In stoats the female is solely responsible for bringing food for the young. In foxes, and other carnivores, there is evidence that the males and non-breeding females [called 'helpers'] are involved in bringing food to the breeding den (Lloyd 1977b; Macdonald 1979). In these circumstances, size may be greatly influenced by additional food provided by the food gathering capabilities of the fox social group.

If it is accepted that food availability is a major determining factor of stoat size, and that food availability is affected by home range size, there would therefore be a relationship between body size and home range size which is dependent on the patchiness of food. This is further discussed later in Section 4.2.1

One trend which apparently conflicts with what is stated above is the size cline of North American stoats (Mustela erminea), which shows increasing body size northwards, as do weasels (see Fig.28). It is possible that patterns of prey availability and possibly cold tolerance have led to this situation.

Factors other than food availability and competition have been mentioned from time to time as being important in determining stoat size, in particular ability to enter small holes [of prey] and the effect of the nematode parasite Skrjabingylus nasicola (e.g. Heptner, Yurgenson, Sludski, Chirkov & Bannikov 1967; Soest et al. 1972; Simms 1979a). In Ireland the wood mouse and shrew are the only common prey animals that are likely to have caused the Irish stoat problems of access associated with size. Yet, Irish stoats do enter wood mouse holes and consume wood mice (4.2.2). However, it is difficult to see how a ubiquitous prey animal could be responsible for the marked variation in stoat size, in particular the north/south size cline.

Levels of damage to stoat skulls by Skrjabingylus nasicola are higher in Ireland than in some other areas (4.2.2). It could be argued that this damage could also be correlated with changes in stoat size, as there have been suggestions that the parasite does affect size (e.g. Soest et al. 1972). However, it has been shown in British weasels and New Zealand stoats by King (1977a) and King and Moody (1982f) that levels of such damage and size are unrelated.

4.1.2 Coat colour

Apart from size, coat colour was the other characteristic which according to the original describers (1.1) set the Irish stoat apart.

Winter whitening in the Irish stoat is very rare, there being only a single known example of complete whitening, and a few examples of partial whitening (Fairley 1971). No examples of such whitening were found during this study (3.1.4). It has been estimated in Russia that when snow cover lies for less than 40 days per annum in a given area, stoats do not turn white (Gaiduk 1977). In Ireland, where snow cover rarely lasts for more than a few days (1.1), winter whitening cannot be expected on this basis. Therefore the lack of winter whitening in Irish stoats can be accounted for by adaptation to the prevailing climate.

Irish stoats have a recognisably darker dorsal coat than British stoats. To measure such colour intensity a reflectance spectrophotometer is used (see Dadd 1970) which was not available during this study. This darker dorsal coat colour of the Irish stoat is not unexpected, as other Irish mammals, for example the otter, and hedgehog Erinaceus europaeus L. are also reported to be

darker than British equivalents (Dadd 1970; Morris 1977). Other Irish animals, notably certain moths, birds and Natterjack toads Bufo calamita Laurenti are also darker (Praeger 1950; O'Rourke 1970). The existence of such darker forms here is considered to be an example of Gloger's Rule: "That animals inhabiting warm and moist regions tend to have more dark pigment than their races in dryer cooler regions". Ireland's climate is very humid and relatively cool. Gloger's Rule is known to be widely applicable to birds (Fisher 1954) and mammals (Searle 1968).

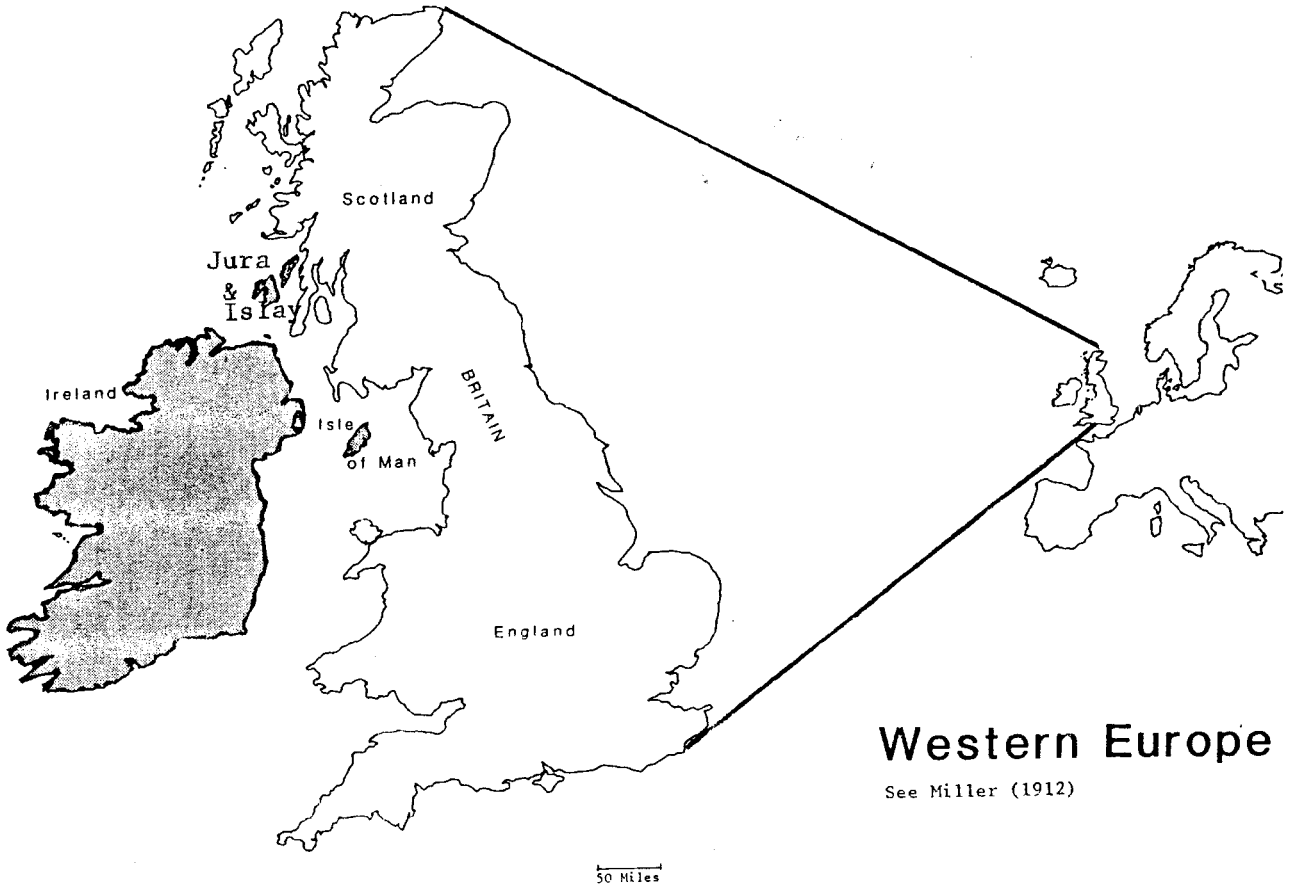
The reduction of the white ventral area of the coat in Irish stoats could be seen as simply an increase in the overall darkening effect due to adaptation to the climate, obeying Gloger's Rule. However, coat colour pattern with the lack of winter whitening is the most reliable distinguishing characteristic of the Irish stoat. Thomas (1895) reported examining stoats from many parts of the world and finding none with such an irregular ventral pattern.

It is now known however that some of the Mustela erminea found on the West coast of North America, i.e. the sub-species : Mustela erminea anguinae Hall; Mustela erminea streatori Merriam; Mustela erminea olympia Hall and Mustela erminea fallenda Hall, which are found in coastal British Columbia including Vancouver Island, and

parts of the States of Washington and Oregon do not go white in winter and some have a similar irregular ventral pattern (Dalquest 1948; Hall 1951; Banfield 1974; D. Norgorsen-pers.comm.; G.E.Svendsen-pers.comm.) (see Fig.29). Similarly, in winter snowshoe hares (Lepus americanus Erxleben) within this area do not go white (Norgorsen 1983). Winter whitening is also rare in Irish hares. These areas in North America are all west of the Cascade Mountain Range and south of the Coast Mountains (Fig.29), and like Ireland have little or no snow cover in winter.

Western coastal areas of the northern continents are warmer in mid-latitudes than those on the east, due to the prevaling atmospheric ciculation and ocean currents. These are areas where there is much rainfall and little snow, within the range of the stoat. The existence of these similar irregularly counter-shaded stoats in Ireland and west of the Cascades in North America supports the suggested association between climate and ventral coat pattern.

Weasels are absent from these north-west American coastal areas. Therefore it could be argued that stoats in these areas like the Irish stoat, are intermediate between stoat and weasel in coat pattern. However on the opposite [east] coast of North America, in for example, New Brunswick, Novia Scotia and the island of Newfoundland weasels are also absent, and the stoats found there



areas of occurrence :

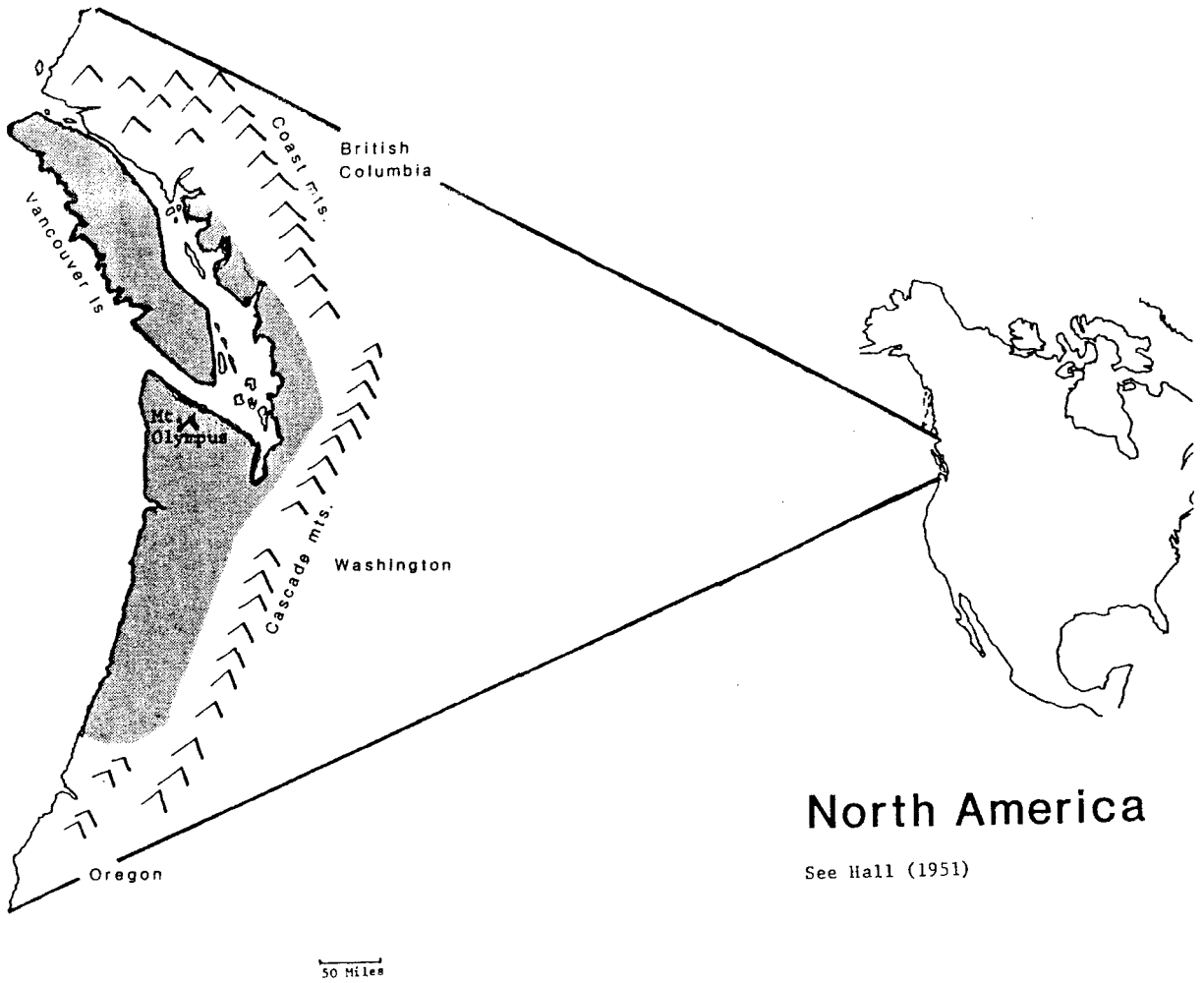


FIGURE 29. AREAS OF WESTERN EUROPE AND NORTH AMERICA WHERE STOATS WITH IRREGULAR VENTRAL COAT PATTERNS OCCUR

(Mustela erminea richardsonii Bonaparte) have regular ventral whitening and become white in winter.

Weasels in Britain only rarely go white in winter and have irregular ventral whitening (Linn & Day 1966; King 1977b). In Sweden there are two races of weasel: Mustela nivalis nivalis L., which is found in the north and Mustela nivalis vulgaris Erxleben which is found in the south (Stolt 1979). The northern race (nivalis nivalis) turns white in winter, and in summer has a regular white underside pattern, like most races of stoat. The southern Swedish race of weasel (nivalis vulgaris) however does not go white in winter and has an irregular white ventral pattern like British weasels, and stoats from Ireland and west of the Cascades in North America [for photographs see Stolt (1981)].

These facts strongly suggest that regular ventral patterns are found in populations of weasel and stoat that turn white in winter and that irregular ventral patterns are found in population that do not. It follows therefore that the irregular ventral pattern of Irish stoats is probably not due to its being an intermediate between stoat and weasel, but rather it is associated with remaining brown dorsally in winter.

Why do populations that do not turn white in winter have irregular ventral patterns ? Winter, when ground cover is least abundant is probably the season when stoats and weasels are most conspicious, particularly to raptorial birds which are considered to be important predators of small mustelids (Errington 1967 & 4.3). Hence when the animal spends a significant amount of time above ground and there is snow cover, small mustelids tend to turn white. The fact that weasels do not turn white except much further north, may be a reflection of the amount of time each species spends above ground, and thus exposed against snow cover. It is now known that the black tip of the stoat's tail, which remains black when the rest of the coat turns white, can function as an anti-avian predator device by diverting the birds attention (Powell 1981). The variation in the tail length of adult male Irish stoats is considered to be suggestive of partial tail loss due to avoidance of such predation (see 4.3).

Counter-shading; dark above and light below, is a term coined by an American artist, Abbot Thayer. He showed it experimentally to be a simple gradation of tones which could make animals inconspicuous (see Page 66 in Pycraft 1925). This pattern is very common in nature, occurring in mammals, birds, reptiles, amphibians, fish, and many invertebrates (Pycraft 1925). Cott (1940) discusses such counter-shading in animals, and because he wrote during World

War II, he discusses the applications of the counter-shading to the camouflage of gun barrels. He showed (Figure 4 in Cott 1940) that the most effective obliterating shading in circumstances where light is coming from above is the graded irregular type.

The ventral pattern found in Irish stoats, stoats from west of the Cascades in North America, and certain weasels, is graded by being irregular, which suggests that it may be an adaptation favoured in those regions where there is little or no snow. There are however populations of stoats that do not go white in winter but nevertheless have regular counter-shading. For example, white stoats are uncommon in southern England (Chapman 1967). It would appear that some degree of geographical isolation of a population has been necessary, such as that caused by the Irish sea or Cascade mountains, in order for irregular countershading to occur in stoats.

Similarly, in limited areas on and around Mount Olympus in Washington State [west of the Cascades] (Figure 29), prolonged snow cover does exist because of the high altitudes . However, in this area the snowshoe hares do not turn white, making them very prominent on snow cover and implies that there is a genetic basis for winter whitening (Nagorsen 1983).

It is likely that winter coat colour has a genetic basis. It has been argued (D.J.Jefferies- pers.comm.) that irregular counter-shading could be linked to a gene or gene(s) that code for some physiological or behavioural character which assists survival in wet climates with little snow cover. This argument is based on the lack of substantial evidence for natural selection for minor changes in coat colour. There is also the example of "brindling" [a minor plumage variation] in guillemots Uria aalge (L.) which is thought to be controlled by a gene(s) linked to a gene(s) coding for physiological adaptation to the cold (Jefferies & Parslow 1976).

However, as discussed above, it appears more likely that the variation in ventral pattern in Irish stoats is a result of natural selection acting on existing variation, rather than linkage. The parallel evolution shown by Irish stoats and stoats west of the Cascades in North America is unlikely to be part of the same linkage phenomenon. It is similar for weasels, which although a different species, appear to respond to variation in snow cover in a similar predictable pattern. It is considered likely that irregular counter-shading in stoat and weasel is an example of parallel evolution.

There is much circumstantial evidence for natural selection of mammal coat colour, the existence of numerous different colour races of mammals being one examples of this. Perhaps the most celebrated of these cases is that of the form of pale coloured house mouse Mus domesticus, discovered on the Bull Island, Dublin, which evidently had evolved in 100 years or so (Jameson 1898). Rapid evolutionary changes in the frequency of darker animals is also well documented, for example the occurrence and spread of dark coated rabbits in Tasmania and the wetter areas of Australia (Searle 1968). Such changes are regarded as adaptations to local environments in terms of concealment as a result of natural selection.

Some laboratory experimental work was done in the nineteen-forties with deer mice (Peromyscus spp.) and owls in the United States. When different coloured soils were used, mice without concealing colouration were heavily predated by the owls, showing that there is significant selection pressure on coat colour in such circumstances (Dice 1947). It was concluded that natural selection could produce very rapid evolution of coat colour if variation existed in a population. Such experimental data coupled with field observations are convincing evidence of the role of natural selection in observed variation in coat colour.

Therefore the Irish stoat, which can only be differentiated by coat colour (see 4.1.1) could have evolved rapidly, and there is no need to explain its presence in Ireland by prolonged isolation or its existence as a relict form.

The presence of a greater proportion of British type, ventrally patterned stoats in the Province of Munster could prompt the suggestion of human-aided introduction of this form, at some time in the recent past, from Britain. A considerable proportion of the Irish fauna is introduced (see Kernan, Mooney & Went 1980; Sleeman, Devoy & Woodman 1986). Mustelids, including stoats, have also been introduced to many islands worldwide, usually in the hope that they would control rodents or rabbits (Lever 1985).

4.2 BEHAVIOUR

4.2.1 Habitat utilisation

The habitats recorded for Irish stoats and English stoats and weasels are compared in Table 33. Both English stoats and weasels had a higher percentage of records from open country than Irish stoats which had a higher percentage from woodland. Given the scarcity of woodland in Ireland relative to England, these results are of interest. Stoats are also reported to be common in New Zealand woodlands (Gibb & Flux 1973; King & Moody 1982c).

In North America and in areas of the Palaearctic where there are large unbroken tracts of forest stoats are reported to avoid woodland (Polder 1968; Vaisfeld 1972; Simms 1979a; Debrot 1981). Instead they prefer open ground in these areas, because their principal prey species there are the open ground species, field voles [*Microtus* spp.] and water voles [*Arvicola terrestris* (L.)]. The fact that woodlands appear to be used by stoats in Ireland and New Zealand may be the result of the absence of such open ground prey species. Rabbits can be regarded as open ground species, however rabbit holes are now rarely in the open, although before myxomatosis it is reported that rabbit holes were often in such

TABLE 33 RECORDS FROM VARIOUS HABITATS FOR IRISH STOAT AND BRITISH STOAT AND WEASEL

	Irish stoat*		British stoat+		Weasel+	
Habitat	n	%	n	%	n	%
Wooded Country	240	46	38	42	26	35
Open Country	223	42	51	57	37	49
Suburban/urban	18	4	1	1	12	16
Seashore	44	8	-	-	-	-
Totals	525	100	90	100	75	100

* Data from Table 10
\+ Data from Sheffield area (Alcock & Warsop 1982) which is inland hence the absence of shore records

areas (Lloyd 1977a). Another cause for the use of woodland could be the widely reported selection by mustelids of areas of cover, possibly because by avoiding open ground they do not expose themselves to increased risk of avian predation. For example pine martens avoid open areas, and are active more or less exclusivly within wooodland or scrub (Hawley & Newby 1957; Warner & O'Sullivan 1982).

It is well known that stoats climb trees both in Ireland (see 3.2.8), Britain (e.g. Southern 1956; Howes 1977; King 1977b; Matthews 1982) and elsewhere (Dalquest 1948; Banfield 1974; Moors 1983). Weasels also climb trees and they have become well known predators of birds and their eggs in nest-boxes throughout Europe (Flegg & Glue 1971; Dunn 1977). In this study radio-tagged stoats were located up trees fairly often at Fota, both in woodland and in open ground (Table 17). This use of trees added a further dimension to the stoats' home range which was unmeasured in this study. As with small mammals which also use arboreal pathways (e.g. Montgomery 1980) the extent that this additional space adds to the overall home range must be considerable and would be worth measuring in any future study. The use of three dimensional home range models, such as that described by Koeppl, Slade, Harris and Hoffmann (1977) should be part of any future study of stoats in woodland.

The extent to which weasels and stoats go up trees when they are sympatric does not appear to have been estimated. The emphasis on weasel predation of bird nest-boxes in the ornithological literature suggests that weasels are more frequent tree climbers than stoats (Krebs 1970; Flegg & Glue 1971; Dunn 1977; Perrins 1979). However, similar predation of nest boxes has been reported from Ireland (e.g. Fagan 1986; P.Smiddy-pers.comm.) which is very likely to be due to stoats. There are reports from Britain of stoats being arboreal there. For example they have been reported being poked out of squirrel drays (Southern 1956; Tittensor 1977) Arboreal traps operated for red squirrels on the Isle of Wight (where both weasels and stoats occur) frequently captured stoats, but not weasels (J.Holm-pers.comm.).

Using the information from bird nest-box predation, it could be suggested that when stoats and weasels are sympatric, weasels predominate up trees and where weasels are rare or absent as in New Zealand and Ireland respectively, stoats exploit this habitat (see Moors 1983 and this study). The increased use of trees by stoats where weasels are absent could explain the frequent use of trees by some of the stoats at Fota and the reported confusion between stoats and squirrels in Ireland (Fairley 1975; Ní Lamhna 1979). This utilisation of a habitat by stoats in allopatry but not sympatry with weasels, fits neatly into the competitive release theory.

However there is very little evidence that weasels and not stoats are responsible for nest-box predation in Britain. It could be argued that the small nest-box entrance hole: 30mm (1.25") (Flegg & Glue 1971) of the most frequently used nest box type may exclude stoats. However, this could only exclude the larger southern male stoats. It is also possible that by reaching into a box the predator does not have to enter it. Other information from Britain suggests that stoats are sometimes arboreal there (see above).

It is probable that the extent of arboreality by stoats and weasels varies with habitat and food availability. In suburban woodland in Britain for example, where weasels would be expected to be predominant, and nest boxes common, therefore it would be surprising if weasels were not the predominant nest predator. Similarly where large prey such as squirrels are available (see above) stoats could be expected. Therefore the arboreality of the Irish stoat cannot be pronounced to be an example of competitive release. However further quantitive information from Britain or other areas where stoats and weasels are sympatric may cast futher light on the subject.

The extent of arboreality is of interest for a number of other reasons. Mature woodland in Ireland is a scarce habitat, in particular woodland with trees with holes suitable for birds, bats and arboreal mammals. Some of the stoats radio-tracked at Fota regularly traversed areas of woodland, tree by tree, presumably searching for prey in such holes.

An interesting consequence of such arboreal behaviour by the Irish stoat could be the exclusion from Ireland of certain vunerable species of tree hole dewllers. Given the limited wooded area available here, stoats regularly decimating any tree hole dwellers that did arrive could have an impact on colonisation. For example it is of interest that three of the relatively large bat species found in Britain and not in Ireland, Bechstein's [Myotis bechsteini], noctule [Nyctalus noctula] and barbastelle [Barbastella barbastellus] are all dependent on tree hole roosts. Small mustelids have been known to prey upon bats (Stebbings & Placido 1975; Hill & Smith 1984). Similarly, tree hole nesting birds such as woodpeckers (Picus & Dendrocopus spp.), redstarts (Phoenicurus spp) and flycatchers (Ficedula spp) are rare in, or absent from Ireland. Indeed, there is a report of breeding of the pied flycatcher (Ficedula hypoleuca Pall.) in Co Wicklow which suffered predation (Fagan 1986). This is likely to have been by a stoat. Predatory exclusion of these species by the stoat is suggested as a factor in their failure to colonise Ireland.

Another interesting aspect on aboreality is its relevance to the problems of island colonisation. It is often suggested that animals may arrive on isolated islands on natural rafts of trees or branches washed out to sea by flood-swollen rivers (e.g. Denman 1965; Sondaar 1976; Yalden 1982) . Clearly the extent to which the stoat climbs trees makes this possibility more likely. However, it should be remembered that weasels also climb trees.

Irish stoats appear to be more frequently recorded from urban/suburban habitats (4%) than British stoats (1%), but less frequently than weasels (16%) (Table 33). This apparently greater use of urban habitats in Ireland could be influenced by the absence of the weasel here, and supports the competitive release hypothesis. Further data are needed to confirm this. The existence of urban wildlife has provoked great interest in Europe and North America in the last two decades, and for this reason the Irish urban /suburban stoats are worthy of further study.

Other aspects of habitat utilisation are the stoat's use of time [movements] and space [home range]. The pattern of movement by stoats in this study was in general similar to that recorded in the literature (e.g. Musgrove 1951; Nyholm 1959). They visited a single part of their home range for a few days (one to three) and then moved on to cover the entire home range in a period of seven to ten days (Fig.21).

TABLE 34. ESTIMATES OF HOME RANGE AREA OF MUSTELA ERMINEA

Country	Method	Habitat(s)	Season(s)	HOME RANGE AREA (ha) Male	Female	Investigator
Finland	Snow tracking	Farmland	Winter	mean = 34 range= 29-40 n = 17	mean = 7.4 range= 4-17 n = 46	Nyholm (1959)
Russia	unknown	unknown	unknown	mean = 20.5 range= 4-49 n = 11	mean = 7.1 range= 0.2-42 n = 28	Zharkov in Nyholm (1959)
Russia	Snow-tracking & circumtous route	Various	Autumn & Winter	mean = 57.3 n = 8	mean = 56 n = 7	Vaisfeld (1972)
Scotland	Trapping	Young pine plantation	Winter	a male = 20.2	none	Lockie (1966)
Sweden	Radio-tracking	Wet meadow	All	mean = 15.1 range= 5-35 n = 5	mean = 4.0 range=2-3 n = 6	Erlinge (1981)
Switzerland	Trapping	Mountain valleys	Summer & Autumn	mean = 21 range= 8-39 n = 6	mean = 5.1 range=1-7 n = 3	Debrot & Mermod (1983)
Canada	Trapping & tracking	Field & Woodland	All	mean = 21.2* range= 16-24 n = 4	mean = 8.3* range= 4-13 n = 8	Simms (1979b)
Ireland	Radio-tracking	Field & Woodland	All	a male= 11	mean =11.3 range=2-22 n = 3	This study

* exclusive boundary strip method

Comparison of the mean daily movement distance (DMD) of stoats from this study and with DMD's from northern and central Russia, Finland, Sweden and Canada (Table 35) shows that those in the northern Palaearctic move greater distances, particularly in Russia. However the Irish stoats in this study had higher DMDs than the small stoats in Ontario. This reflects the variable home range sizes which can in turn be expected to result from differing prey availability (see below).

With few measurements of home range in this study it would be incorrect to draw too many conclusions, except in the case of the one [Sally's] which is considered complete (Table 14). The relatively large size of her home range is considered likely to be the result of an expansion of the area during the period when she was rearing young. Expansion of the home range of breeding female stoats was predicted by Lockie (1966) on the basis of his work on weasels. The literature shows that home ranges for stoats are very variable across their range, from 0.2 to 40 hectares (Table 34). Usually home range of males are larger than that of females and include the latter (King 1983a). It seems that most mustelids have this same basic pattern (Powell 1979a).

It is known that the nutritional requirements of female mammals during lactation are very high, and that the young stoats grow most

TABLE 35. ESTIMATES OF DAILY MOVEMENT DISTANCES (DMD) OF MUSTELA ERMINEA.

Country & Area	Method	Season(s)	DAILY MOVEMENT DISTANCES (m) Males	Females	Investigator
Russia : Northern	Snow-tracking	Spring & Autumn	mean = 2746 n = 15	mean = 2015 n = 7	Vaisfeld (1972)
Finland : Joensuu	Snow-tracking	Winter	mean = 520 n = 1	none	Nyholm (1959)
Russia : Central	Snow-tracking	Winter	[unsexed mean = 2070 n =13]		Kraft (1966)
Sweden : Revinge	Radio-tracking	All	mean = 1230 n = 7	mean = 714 n = 10	Erlinge (1979)
Canada : Ontario	Trapping & tracking	Spring, Summer & Autumn	mean = 151.7 n = 4	mean = 137.9 n = 4	Simms (1979)
Ireland : Cork	Radio-tracking	Summer & Autumn	mean = 250 n = 1	mean = 241.3 n = 3	This study

rapidly during the first months of life (see 4.1.1). It is also known that female mustelids during pregnancy and lactation change their behaviour towards males and become dominant (Lockie 1966; Erlinge 1977b; Östman, Hillegaart & Sandegren 1984). The large home range of Sally is considered to be a result of these factors and primarily caused by her need for additional prey. It is possible that in Ireland, with the few species of mammal prey available, this phenomenon is more pronounced and therefore more easily detected. However, it is likely to occur elsewhere. It is of interest for example that in New Zealand more females were trapped in summer than at other times of the year (King & Moody 1982c), possibly indicating similar home range expansion. A recent review (Linstedt, Miller and Buskirk 1986) also predicted such home range expansion generally in breeding female carnivores.

The literature on home ranges of British stoats and weasels is sparse, although a paper by Pounds (1978) announced that home ranges in Scotland for both species were bigger than previously detected but no actual data are yet available from his study. The available information suggests that male British stoats have a home range of 20ha (Lockie 1966), while male British weasels have a home range of 7 to 15ha (Moors 1974; King 1975a). The detected home range of the male Irish stoat in this study is 10ha, however it is based on incomplete home range. When Sally's home range is

considered, she had a remarkably large home range for a female stoat in a temperate country (see Table 34). Female home ranges of similarly large size have perviously been found in Russia in autumn and winter (Valsfeld 1972). While her home range is regarded as being as the result of her increased need for food during breeding it nevertheless does not accord with the concept that the Irish stoat is an intermediate form between the British stoat and weasel. It is also known that radio-tracking produces larger calculated home ranges than trapping (Linstedt et al. 1986) presumably because it is a more accurate method. This makes Sally's large home arnge less surprising when compared to those previously measured by trapping (e.g. Lockie 1966; Debrot & Mermod 1983 see Table 34).

There is now little doubt that animal size and home ranges are positively correlated, and many authors have dealt with interspecific comparisons (e.g. McNab 1963; Jewell 1966; Harestead & Bunnell 1976). However, whereas size may be a good predictor of home range in general there are exceptions. Take for example the arctic fox Alopex lagopus (L.), which is smaller than the closely related red fox, Vulpes vulpes. In a study of such foxes in Iceland and England it was found that the smaller arctic foxes had much larger home ranges (Hersteinsson & Macdonald 1982). Clearly, in a prey impoverished area such as Iceland, a carnivore will need a larger home range to forage over than in a relatively prey rich area such as southern England.

If stoats throughout their range are examined the largest home ranges are found in cold northern areas such as Finland and Russia (Table 34). These are also areas of relatively small stoats. Considered together these facts would appear to challenge the now accepted concept of a positive relationship between size and home range. Most authors would agree that stoat density is determined largely by prey density (e.g. Valsfeld 1972; Debrot 1981; Taylor Tilley 1984). Other studies of carnivores have reached the same conclusion for example : the Egyptian mongoose Herpestes ichneuman (Dellbes & Beltran 1985); golden eagle Aquila chrysaetos (L.) (Tjernberg 1984), and foxes [arctic and red] (see above).

The data on home range and habitat utilisation in this study are limited. With radio telemetry, using anal scent gland as a trap bait, further studies would be worthwhile.

4.2.2 Food Habits

Weasels are considered to specialise on small mammal prey taking mainly small voles but the staple prey of stoats is considered to be mammal prey of rabbit/water vole size (King 1977b; Matthews 1982). Data from studies of the food habits of stoats and weasels confirm these assertions (e.g. Day 1968; Fairley 1971; Walker 1972; Potts and Vickerman 1974; Moors 1975; Erlinge 1975; Tapper 1976; Brugge 1977; Simms 1979a; King 1980b). On mainland Europe the water vole is often the staple prey item of stoats (e.g. Kilmov 1940; Kraft 1966; Erlinge 1981; 1983; Debrot 1981; 1983; Debrot, Fivaz & Mermod 1984), just as they may have been in Britain prior to the introduction of rats and rabbits (see below). In Britain the staple prey of stoats is now rabbits and the stoats dependence on rabbits was dramatically illustrated by the sharp decline in stoat numbers reported after myxomatosis (e.g. Jefferies & Pendlebury 1968; Hewson 1972; King & Moors 1979a; Sumption & Flowerdew 1985). This decline is also considered to have occured in Ireland (Fairley 1984). Rabbits live in relatively large holes. Their predominance in the stoat's diet makes arguments which quote size of prey holes as a selection pressure for small stoats here, somewhat irrelevant.

Published data on stoat and weasel food habits in Britain are compared with this study's results for Irish stoats in terms of the

TABLE 36 PERCENTAGES OF MAJOR PREY IN DIETS OF IRISH STOAT COMPARED WITH RANGE OF PERCENTAGES IN BRITISH STOATS AND WEASELS

Prey	Irish stoat [This study]	British stoat [see below]	British weasel [see below]
Lagomorph	32	34 - 56	0 - 22
Rat	14	0 - 3	0 - 14
+Small mammals	35	6 - 29	43 - 76
*Birds	19	12 - 41	10 - 28

+ including shrews * including eggs

British stoat data from Potts & Vickerman (1974) and Tapper (1976), British weasel data from Day (1968); Potts & Vickerman (1974); Walker (1972); Moors (1975); Tapper (1976) and King (1980) [see Appendix 8:B]

range of percentage occurrence of prey types in Table 36. From this the predominance of rabbits in the diets of stoats, and small mammals in weasel's, is clear and other trends are evident. British weasels are known to eat more rats (14%) when available, whereas British stoats appear to eat more birds (see Appendix 8:B).

In keeping with the predictions of the competitive release hypothesis, the food habits of the Irish stoat appear to have characteristics of both the British weasel and stoat. The Irish stoat had fewer rabbits but more rats in its diet than had the British stoats. It had more rabbits than the weasel, but slightly fewer rats than reported incidence of rats in British weasels' diet (Table 36).

More significantly perhaps the Irish stoat diet contained proportionately more small mammals than did the British stoat's diet but fewer than in the British weasel's diet. Indeed small mammals are more numerous than rabbits in the diet of the Irish stoat, but they are less important in terms of biomass (Table 22). Shrews make the most important contribution to this prey type for the Irish stoat. It has been widely reported in the literature that shrews are not eaten by stoats or by other carnivores because they are distasteful (e.g.Lockle 1959; King 1977b; Simms 1979a; Erlinge 1981; Fairley 1984). However the results of this study and some

North American, Russian and Swedish work (e.g. Hamilton 1933; Aldous & Mannweller 1942; Kraft 1966; Heptner et al. 1967; Erlinge 1981; Jenning, Threlfall & Dodds 1982; Aitchison 1987) show that this is not always true. It appears that when prey is scarce and the animal is hungry enough, not only stoats but also foxes, martens, mink and weasels will eat shrews (Weckworth & Hawley 1962; Linn 1961; Macdonald 1977; Cuthbert 1979).It has been found that a captive weasel actually prefered shrews to other prey (Erlinge 1975), so it is possible that some mustelids can adapt to having shrews as a regular prey item. Nevertheless the relatively large numbers of shrews reported here in the diet of the Irish stoat suggests that the stoats are eating these less-favoured prey because of the lack of other suitable prey species.

This eating of shrews could be regarded as a weasel characteristic. Although there are occasional records of British stoats eating shrews (e.g. Howes 1977), as well as by stoats elsewhere (see above), the frequent eating of shrews is a food habit much more associated with weasels (Day 1963; Heptner et al. 1967; Moors 1975; Brugge 1977). The eating of a greater percentage of small mammals and the fact that many of them were shrews, can be regarded as support for the competitive release hypothesis. However it is not known whether this is due to the absence of the weasel here, or to a difference in prey availability.

The fact that shrews may be the principal paratenic host of the parasitic nematode Skrjabingylus nasicola may have influenced the extent of the infestations and therefore the damage done by this parasite (3.5.3.). The rate of such damage in the Irish stoat (50%) was apparently higher than that found in stoats in Britain (17-31%) and in most instances in Europe (20-50%) (Appendix 6:C). It is therefore tempting to suggest that the role of shrews in the Irish stoat's diet and the high rate of damage to the skulls are related. In a similar vein, Duncan (1976) suggested that in Britain it was during the critical period of rearing young that females were forced to eat shrews, and hence acquired the parasite. These arguments lose some of their force when it is realised that stoats in New Zealand, where there are no shrews, suffer from this parasite (King 1974), while there is also the recent discovery in Switzerland that woodmice can also act as a paratenic host (Weber & Mermod 1983).

It is likely that in Ireland the notoriously humid climate affects survival rate of larval Skrjabingylus nasicola, since it is known that they need high humidities to survive. Indeed the rate of damage to both weasel and stoat skulls elsewhere has been successfully correlated with mean number of rain days (Hansson 1974; King 1977a). It is therefore climate rather than diet that is considered to be responsible for the high rate of parasite damage

to stoat skulls. It has been suggested that stoats infected by this nematode might be more prone to become car accident victims and hence this study'd sample would be biased in favour of infected animals. However data on damage to stoat skulls in this study contradicts this idea (see 3.5.3).

The small number of records of bank voles (3) found during the diet study is puzzling, particularly as the Irish stoat is apparently short of suitable small prey. Other authors have found bank voles to be scarce or absent in the diets of stoats (Erlinge 1981), weasels (Moors 1975) and pine marten (Lockie 1961), despite being common in the study areas. However, bank voles are reported to be common prey of weasels in woodland in Sweden (Erlinge 1975) and England (King 1980b). It has been suggested by Erlinge (1981) that in stone wall and hedgerow habitats bank voles can take refuge in narrow places and avoid predation. By implication this is not always possible in woodland. It is of interest therefore that the records of bank voles in stoat guts during this study came from woodland (Table 25). Experimental work with laboratory colonies of voles, mice and mustelids might provide a solution to this apparent anomly.

The fact that the Irish stoat's diet varies seasonally and between habitats tallies with the results of studies of small mustelid diet

elsewhere, for example British weasels (King 1980b) and Swedish stoats (Erlinge 1981). The fact that male Irish stoats eat more large prey than the females do reflects a trend found elsewhere for stoats, weasels and other mustelids (Day 1968; Erlinge 1975, 1981; Brugge 1977; Simms 1979b; Moors 1980; King & Moody 1982b). The conclusion that the Irish stoats eat more weasel-like prey reflects their eating of rats and shrews - both prey being abundant on roadsides where most of the stoats, being road casualties, were found. Whereas the importance of birds is probably exaggerated in investigations of stoats and weasls which are based on carcases from gaming estates (e.g. Day 1968; Fairley 1971), a sample of road casualty British stoats may well show similar dietary trends, i.e. eating shrews and/or rats.

The principal prey of the stoat in these islands today is the rabbit, but this must be a recent phenomenon as the rabbit was intorduced within the historic period (Lloyd 1977a). There is evidence that before rabbits and rats were introduced to Britain, water voles, Arvicola terrestris (L.) were more common and found in a wider variety of habitats. Studies of ancient pellets of birds of prey have shown that water voles were common prey in dry areas where they are not found today and it has been suggested that they were displaced from all but the wettest habitats in Britain by introduced rabbits and rats (Jewell 1959; Yalden 1977). The water

vole is not morphologically equipped for aquatic habitats and on mainland Europe it is reported to be less aquatic than in Britain (Stoddart 1977). Therefore it is likely that, as in much of Europe today (see above) the water vole was once the principal prey of stoats in Britain.

The fact that rabbits are now the principal prey of stoats in Britain and Ireland may well be responsible for the comparatively large size of stoats in these islands (see 4.1.1 and Table 33). King and Moody (1982c) have argued that the large size of female stoats in New Zealand is due to the preponderance of rabbit in their diet.

The critical growing season for young stoats is May, June and July. When rearing the young, the female stoats probably raid rabbits' nests for nestling and carry them off to their young (3.3.1). Such rabbit nestling provide an accessible and portable food source which can be overlooked in studies of diet based on hair identification, as the nestling can be naked. It is suggested therefore that the large size of stoats is a result rather than any adaptation to predating on rabbits.

Further research work on the Irish stoat would be necessary to confirm the putative character release proposed here in terms of

the role of small mammals in the diet. The diet of the stoat in different habitats with imporved prey identification techniques (e.g. Walsh & Sleeman 1985) would make a worthwhile future study. Particular attention has always focussed on the role of birds in stoat diet, particularly in relation to young gamebirds (e.g. Tapper 1978). However further work during the critical months [for both stoats and birds], of May,June and July, identifing fledgling birds taken by stoats would also be worthwhile.

4.3 MORTALITY AND PREDATORS

The time and cause of death are important in an animal's ecology. The detected age of the stoats sampled showed that many die when young (Appendix 4) and probably most die in the first year of life. This has also been found in stoats sampled elsewhere, for example in the Soviet Union (Kopein 1967), Denmark (Fog 1969), Holland (Soest & Bree 1970), Sweden (Erlinge 1983), Switzerland (Debrot 1984) and New Zealand (Grue & King 1984). Generally, both stoats and weasels are described as short-lived, although stoats may have a longer maximum life span. The fact that Irish stoats appear to have a mean life expectancy of < 1 year is therefore not exceptional and given current information, makes them no more weasel like. However, to date, the aging of Irish stoats has been relatively crude. Detailed ageing information may yet show that population structures for Irish stoats differ from those found in other stoat populations.

There is some evidence that stoats in northern latitudes in Russia have a slightly shorter life span [1 year or less] than stoats in more southern latitudes [1.5 years] (Kopein 1967). Given continuous growth, the different longevity of the stoats at different latitudes could account for the north/south cline in size. However it is known that most growth takes place in the first 120 days of

life, therefore any role of longevity in size clines would be small.

The time of death is likely to reflect aspects of the stoat's behaviour which puts them most at risk. For example trends in seasonality of road casualties [vehicles can be regarded as predators] suggest that expansion of the home range leads to such casualties. Thus the expansion of the home range by males in the spring (Erlinge 1977a, 1980), and proposed expansion by females with young, appears to lead to greater numbers of deaths [It is of interest that one of Erlinge's radio-tracked male stoats was killed by a vehicle in the spring during his study (Erlinge 1977a)]. Similarly, dispersal of young stoats leads to their becoming road casualties in June, July and August (Fig.7; 3.1.1).

There is no evidence, as yet that road casualties are a particularly important cause of mortality in overall stoat populations. Road casualties appear to be an important cause of death for Irish stoats because they provided 82% of the specimens for this study. However this is a very biased sample since roads were a focus of attention for those who collected the stoats (3.1.1).

For females there is evidence that they become dominant over males during preganacy and lactation, whereas they are subdominant for the remainder of the year (Erlinge 1977c). The same appears to be true for other mustelids (4.2.1). The breeding female [Sally] radio-tracked during this study had a relatively large home range (Fig 20), which may well have been expanded. The same is possibly true for all female stoats (4.2.1), as predicted by Lockie (1966) and has been predicted for all breeding female carnivores (Lindstedt et.al. 1986).

Female stoats road casualties peaked at this time of year. Taking these observations into account it is evident that when stoats enlarge their home range, they presumably cross more roads and are therefore at greater risk from vehicles. Young stoats are killed in July and August (Fig.7) when they are dispersing. It is of interest that Thompson and Fairley (1978) reported successful stoat trapping in June and July, which they associated with dispersal. This pattern of road casualties has been reoprted for stoats in New Zealand and in other mammal species (e.g. badgers in Briatin see Jefferies 1975; Davies, Roper & Stepherdson 1987).

The few "natural" [non trapped] causes of death recorded were those due to other carnivores (3.1.1). These were mainly caused by domestic dogs, but also by a cat and a suspected death due to an

otter (3.1.1). Irish stoats have previously been recorded as prey for a wide variety of predatory mammals including : fox (Edwards 1899), pine marten (Warner & O'Sullivan 1982) and domestic cats and dogs (Fairley 1975; Pack-Beresford 1936). They have also been reported as prey of a kestrel Falco tinnunculus L. (see Fairley 1975) ,possibly a gull Larus sp. (Smiddy 1984) and a pike Esox lucius L. (Longfield 1901). In a Mammal Society survey of "What the cat brought in" in Britain during 1979/80 a total of seven weasels and three stoats were recorded (C.Howes- pers.comm.). These data show that British weasels and stoats are taken and presumably killed by cats.

Elsewhere across the stoats' range many large carnivores have been reported as predators (Heptner et al. 1967; Errington 1967; Banfield 1974; King 1982; Svendsen 1982). Yet it appears that mammal predators rarely exclude stoats fromm an area. In Ireland, for example pine martens are known to eat stoats (Warner & O'Sullivan 1982), yet stoats were trapped regularly at an occupied marten site in Co. Clare (P.O'Sullivan- pers. comm.). It has been suggested that the introduced American mink, Mustela vison Schreber might displace stoats (Gatins 1979). Mink could possibly outcompete stoats for prey, or they could directly prey on stoats. It is reported that they eat small mustelids (Vershinin 1972; Cuthbert 1979). Since the niniteen fifties mink have spread across Ireland

(Deane & O´Gorman 1969; Crichton 1974; NiLamhna 1979; Fairley 1980), and by the time of this study they were found in virtually every Irish county (Smal in prep.).

Birds of prey [owls,falcons and eagles] are frequently recorded as predators of stoats (e.g. Gush 1948; Musgrove 1951; Heptner et al. 1967; Errington 1967; Powell 1973; King 1982; Brunton & Reynolds 1984; Muir & Bird 1984). For example, most European birds of prey eat small mustelids, usually weasels or stoats (Cramp, Simmons, Gillmor, Hallom, Hudson, Nicholson, Ogllvie, Olney, Roselarr, Voos, Wallace & Wattel 1980). The stoat has even been recorded in the diet of the grey heron Ardea cinerea L. (e.g. Lowe 1954; Owen 1974). There is also evidence that predation by birds is important, as experiments have shown that the black-tipped tail of stoats appears to have evolved to confuse such predators (Powell 1981). There exists a traditional and anthropomorphic concept that predators do not eat other predators, maintaining a chivalrous attitude towords each other (see Errington 1967 Chapter 4). This concept makes it difficult to accept that birds of prey severely predate stoats.

Nevertheless there is little doubt that such predation can, and does, affect stoat and weasel populations (Errington op.cit). As well as providing selection pressure for evolution of cryptic coat

colouration, such predation may also mediate competition between similarly sized small mustelids, thereby explaining their co-existence (Powell 1973).

In Ireland there is, as yet, no firm evidence that birds of prey regularly kill stoats. There is an account of an attack by a kestrel (see above). However, while the diets of most Irish birds of prey, particularly owls, have been studied (e.g. Fairley 1984 Chapter 7 ; Walsh 1984), there have as yet been few long-term studies of such diets here. Given that the stoat is relatively rare in the environment, only long term studies, invoilving many prey items, of the larger birds of prey, could be expected to detect the stoat as prey. It is predicted that should such studies be carried out, the stoat would be found as a prey item. It is suggested that loss of tail length in adult male Irish stoats (see above) may be associated with failed attempts by such predators, which were successfully deflected by the tail, the stoat losing some of the tail in the process.

4.4 CONCLUSIONS

The Irish stoat has to date been regared as a "good" subspecies (Dadd 1970; Matthews 1982). However, the concept of subspecies has itself been rejected by various authors (e.g. Wilson & Brown 1953; Burt 1954), mainly because subspecies often represent what has subsequently emerged to be continuous variation due to geographical clines. More recent authors have however defended the concept of the subspecies especially where the population so described is discrete entity, such as on an island (Corbet 1970; Baker 1985).

The Irish stoat is recognisable by its darker dorsal coat colour (Dadd 1970); however this difference has not yet been quantified. None of the Irish stoats in this study had white on their ears whereas British stoats have. In variation in the ventral coat pattern 96% of Irish stoats can be recognised as different from British stoats by having incompletely white or non-white upper lips. In terms of variation on the remainder of the underside, 87% of Irish stoats were distinct from British stoats, with irregular rather than regular counter-shading (3.1.4).

Thus the Irish stoat occurs in physically isolated populations; Ireland and the Isle of Man, differing from other stoats in several coat colour characters above the 84% level set by Pimental (1959).

It can therefore be accepted as a "definate" subspecies (sensu Corbet 1970). The presence of stoats with irregular counter-shading on the Scottish islands of Islay and Jura (Fig.29) is again likely to be for the same reason. They are at present referred to as Mustela erminea ricinae Miller. it would be reasonable, given that the stoat on the Isle of Man is also called "Irish, to include these stoats in the Irish subspecies.

The coat colour of the Irish stoat is similar to that found in some stoats on the western coast of North America (for distribution see Fig.29). There are indications that the Irish stoat and some stoats on the western coast of North America have evolved the same ventral coat pattern in response to similar environments that lack snow cover (4.1.2). This is regarded as an example of parallel evolution. Swedish studies indicate that a similar pattern is followed in weasels (Stolt 1982,1983).

The difference in size between the Irish and British stoats has been exaggerated in the past by biased sampling (1.1). Size of the Irish stoat is considered to be decided largely by prey availability over the first months of life (4.1.1), therefore an adaptation caused by local environments. Further work to measure prey availability to stoats north and south is required to confirm this hypothysis. The Irish stoat is not uniformly small, indeed in

the south of Ireland it is relatively large, compared with stoats elsewhere (Table 32). The large size of such southern stoats, like that of stoats in Britain and New Zealand, is considered to be a result of feeding young on rabbits, particularly rabbit nestlings. There is a trend which has been interpreted as a north/south cline in size in the Irish stoat within Ireland (Fairley 1981; see also 3.1.5). This is considered to be due to differences in prey availability in the first months of life (see above) which in turn may be due to the marked differences in the length of the growing season between northern and southern Ireland, reflected in the measured grass-growing season (4.1.1). There is an indication from the ventral coat patterns of some Irish stoats that there may have been an introduction of British stoats in the past (4.1.2). If this is true and the introduction was in the south of the country, which the distribution of coat patterns suggests, than it is also possible that such an introduction is in some way responsible for the size cline.

The results of this study do not serve to support the existance of general morphiolgical character displacement in British stoats and weasels, because the Irish stoat clearly is not morphologically an intermidiate form. Other workers have also failed to find morphological character displacement in mammals, for example Davis (1977) who studied fox size, and Stebbings (1973) who studied size

in bats. Both workers concluded that climatic factors rather than competition influenced size variation. Some workers have reported character displacement/competitive release by looking at the size of jaws in mammals, and other skull measurements, as Hutchinson (1959) did. A more recent example is the work of Malmquist (1985) who showed competitive release in pygmy shrews in the absence of the common shrew, using lower jaw measurements. It would be of interest to apply such techniques to British stoats, weasels and Irish stoats.

There is evidence however, that by eating many small mammals and by existing in urban/suburban habitats Irish stoats could be showing behavioural competitive release. These could be called examples of niche shift, the former a dietary shift and the latter a habitat shift sensu Diamond (1970a). These areas are worthy of further study. Behavioural examples of competative release are not uncommon and examples have stood the test of time longer than ,most examples of morphological character release (e.g. Diamond 1970a & b; Grant 1972; Wallin 1985). There is the widely accepted theory that morphological variation is an adaptation to wider niches on islands (e.g. Valen 1965) (see 1.3). The stoat in Ireland does show a great deal of morphological variation, however in this case it is considered to be the result of its environment, rather than an adaptation to it

TABLE 37 MAMMAL PREDATORS AND PREY IN BRITAIN AND IRELAND

IRELAND		BRITAIN	
Predators	Prey	Predators	Prey
Fox	Pygmy shrew	Fox	Mole
Badger	Red squirrel	Badger	Pygmy shrew
Otter	Irish hare	Otter	Common shrew
Stoat	*Rabbit	Weasel	Water shrew
Pine marten	*Wood mouse	Stoat	Red squirrel
+Wolf	*House mouse	Polecat	Brown hare
+Wild cat	*Common rat	Pine marten	Mountain hare
+Brown bear	*Ship rat	Wild cat	Dormouse
*Mink	*Vole	+Lynx	Harvest mouse
	*Grey squirrel	+Wolf	Wood mouse
		+Brown bear	Yellow-necked mouse
		*Mink	Bank vole
			Water vole
			Field vole
			*Rabbit
			*Grey squirrel
			*Edible dormouse
			*Common rat
			*Ship rat
			*House mouse

* Introduced + Extinct. For scientific names see Appendix 12

The difficulty remains of explaining why two apparently closely related animals as similar as stoats and weasels can coexist. One fresh approch would be to re-examine their taxonomic affinities (see McInerney 1986). Another would be to examine wheather competition between them, if such exists, is mediated by predation, particularly by raptorial birds (see Powell 1973). The general idea that predation can allow similar species to co-exist has recived some support, under certain conditions, in the literature (see Schoneener 1983; Giller 1984). A more detailed analysis of their habitat preferences, particularly in regard to their use of urban/suburban habitats and trees may cast more light on how they coexist.

There are some aspects of the history of the stoat in Ireland which it is pertinent to discuss here. For example the stoats presence here is not surprising as it is found widely distributed on off-shore islands. Its colonisation of Ireland is likely to have been facilitated by the fact that it swims well (King & Moors 1979) stoats are known to frequently colonise islands in New Zealand and Canada (Taylor & Tilly 1984; Cairns 1985). Its arboreal habits make it a likely candidate for rafting (4.2.1) and its reproductive biology is suited to colonisation (King & Moors 1979). The possibility of one, or more introductions by man cannot be overlooked (4.1.2).

However, once Ireland was colonised in prehistoric postglacial times that stoat would have been in an area where most, if not all, rodents and rabbits were absent. There were also up to eight other species of mammalian carnivore present (Table 37) all of which, to a greater or lesser extent, eat small mammals. This situation the author has referred to elsewhere (Sleeman 1986 Appendix 13) as the "prey gap". and the very survival of the stoat here during this time has been questioned. It is possible that it survived on the seashore during this period (G.B.Corbet-pers.comm.) as it is reported to trive on such habitat in many areas, for example New Zealand (King 1982; Taylor & Tilly 1984).

It has been argued by Beirne (1947) that the Irish stoat is a relict form, which was more widespread in the past. There is no evidence that the Irish stoat was more widely distributed thenit is now. There is evidence however that it is adapted to the Irish (&Isle of Man) present day environment. The idea that island mammal forms represent relict forms has now largely been rejected both sides of the Atlantic (Corbet 1961; Foster 1965). There exists no reason to regard the Irish stoat as a relict form. The Irish stoat, like other island forms, should be regared as a form determined by its present day environment, both biotic and abiotic.

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PERSONS MENTIONED IN TEXT/ PERSONAL COMMUNICATIONS

Dr G.B.Corbet, British Museum (Natural History), Cromwell Rd
London, England

Dr W.Eichler, Museum fur Naturkunde der Humboldt Universität Zu
Berlin, GDR

Prof.S.Erlinge, Dept'of Animal Ecology, University of Lund,Sweden

Dr D.I.Gibson, British Museum (Natural History) Cromwell Rd
London England

Dr J.Harman, Royal Scottish Museum, Edinburgh, Scotland

Mrs E.Hazelwood, 44 Rigby Lane, Bolton, York, England

Ms J.Holm, Department of Zoology, Royal Holloway and Bedford New
College, Englefield Green, Surrey, England

Dr W.I.Montgomery, Zoology Department, Queens University, Belfast

Dr D.Nogorsen, British Columbia Provincial Museum, Vic' Canada.

Mr P.O'Sullivan, Forest and Wildlife Service, Drumcliff, Ennis
Co Clare

Mr W.O'Sullivan, Zoology Department, University College, Cork

Mr C.Owen, Keythorpe Lodge, Keythorpe, Leicestershire, England

Dr C.Smal, Palm Oil Research Institute, PO Box 10620,
Kuala Lumpur, Malaysia

Mr P.Smiddy, Wildlife Ranger, Ballykenneally, Ballymacoda,
Co Cork

Dr G.E.Svendsen, Department of Zoology and Biomedical Science,
Ohio University, Athens, Ohio, United States

Dr G.I.Twigg, Department of Zoology, Royal Holloway and Bedford
New College, Engleford Green, Surrey. England

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APPENDIXES

Appendix 1 - Irish endemic mammals and birds.
Appendix 2 - Mustelids examined in the study.
A: Origins of Irish stoats from Ireland
B: Origins of Irish stoats from the Isle of Man
C: Origins of British stoats and weasels.
D: Poster used to solicit stoats.
E: Reprint of "Irish Road Casualty Mammals".
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B: Museum specimens donated during the study.
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Appendix 5 - Form
A: Chi-square tests of young and adult stoats.
B: Sexual size dimorphism in Irish stoats.
C: Size of British stoats weasels and Isle of Man stoats.
D: Stoats size in woodland from vole and non-vole areas
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A: Stoat's guts examined and prey remains found
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B: Sizes of British and Irish foxes, mink and otters.
Appendix 13 - Reprint of "Irish carnivores-Problems with their arrival and survival"

APPENDIX 1 IRISH ENDEMIC MAMMALS AND BIRDS

Original scientific names only are given. Currently accepted sub-species are indicated by an asterisk

MAMMALS

Pygmy shrew	Sorex rusticus hibernicus Jenyns 1838
*Irish hare	Lepus hibernicus Bell 1837
Wood mouse	Mus sylvaticus celticus Barrett-Hamilton 1900
Brown rat	Mus hibernicus Thompson 1837
*Irish stoat	Putorius hibernicus Thomas & Barrett-Hamilton 1895
*Irish otter	Lutra roensis Ogilby 1834

BIRDS

+*Irish red grouse	Lagopus scoticus hibernicus Kleinschmidt 1919
*Irish jay	Garrulus glandarius hibernicus Witherby & Hartert 1911
Irish coal tit	Parus ater hibernicus Ogilvie-Grant 1910
Irish tree creeper	Certhia familiaris meinertzhageni Clancey 1942
*Irish dipper	Cinclus cinclus hibernicus Hartert 1910
Irish skylark	Alauda alauda theresae Meinertzhagen 1947
Hebridean dunnock	Prunella modularis hebridium Meinertzhagen 1934
Irish meadow pipit	Anthus pratensis theresae Meinertzhagen 1953

compiled from the following sources: Praeger (1950); Dadd (1970) Corbet & Southern (1977); Kennedy, Ruttledge & Scroope (1954); Boyd, Witherby, Jourdain, Tricehurst and Tucker (1945); Fisher (1966); ; Perrins (1979); Hutchinson (pers.comm.) and O´Riordan (pers.comm.).

+ The Irish red grouse is regarded as now indistinguishable because of introductions and restockings from Britain (Fisher 1966).

APPENDIX 2 MUSTELIDS EXAMINED IN THE STUDY

A : Origins of Irish stoats from Ireland.

County	Numbers		Sex			Case of death		
	Total	%	oo	oo	Unsexed	Rd Casualty	Other	Trapped
Cork	96	48	64	27	5	80	7	9
Tipperary	26	13	18	5	3	23	3	/
Kerry	13	6	10	3	0	12	/	1
Clare	10	5	8	2	0	9	/	1
Galway	7	3	5	2	0	7	/	/
Wexford	6	3	2	4	0	6	/	/
Waterford	5	2	3	2	0	4	1	/
Offaly	4	2	3	0	1	4	/	/
Limerick	4	2	4	0	0	4	/	/
Donegal	4	2	4	0	0	3	/	1
Sligo	3	1	2	1	0	3	/	/
Down	3	1	0	3	0	/	/	3
Kildare	2	1	2	0	0	1	1	/
Rosscommon	2	1	1	1	0	2	/	/
Westmeath	2	1	1	1	0	2	/	/
Laois	2	1	1	1	0	2	/	/
Dublin	1	.5	1	0	0	/	1	/
Mayo	1	.5	1	0	0	/	/	1
Carlow	1	.5	1	0	0	1	/	/
Derry	1	.5	1	0	0	1	/	/
Meath	1	.5	0	0	1	/	1	/
Unknown	4	2	2	2	0	/	4	/
	198		133	55	10	165	15	18
percentages of total			70	30	5	82	7	11

B: Origins of Irish stoats from the Isle of Man

Area	Date	Cause of death	Collector
Kerrokeil Cross Roads	May 1983	Road Casualty	H.S.Collister
Glen Maye	July 1982	Cat	Mr Tinkler
Patrick	September 1982	Road Casualty	I.Radcliffe

C: Origins of British stoats and weasels

Area	Date	Cause of death	Collector
STOATS			
Sufflok	June 1985	Road casualty	N. Chapman
Moulton	" " "	Road casualty	N. Chapman
Knottingly Yorks	September 1985	Road casualty	K.Burden
Fordingbridge Hants	April 1985	Fenn Trapped	S.C.Tapper
" " " "	" "	" " "	" "
" " " "	" "	" " "	" "
" " " "	" "	" " "	" "
" " " "	" "	" " "	" "
WEASELS			
Fordingbridge Hants	June 1985	Fenn Trapped	S.C.Tapper
" " " "	" "	" " "	" "
" " " "	" "	" " "	" "
" " " "	" "	" " "	" "
" " " "	" "	" " "	" "
" " " "	" "	" " "	" "
" " " "	" "	" " "	" "

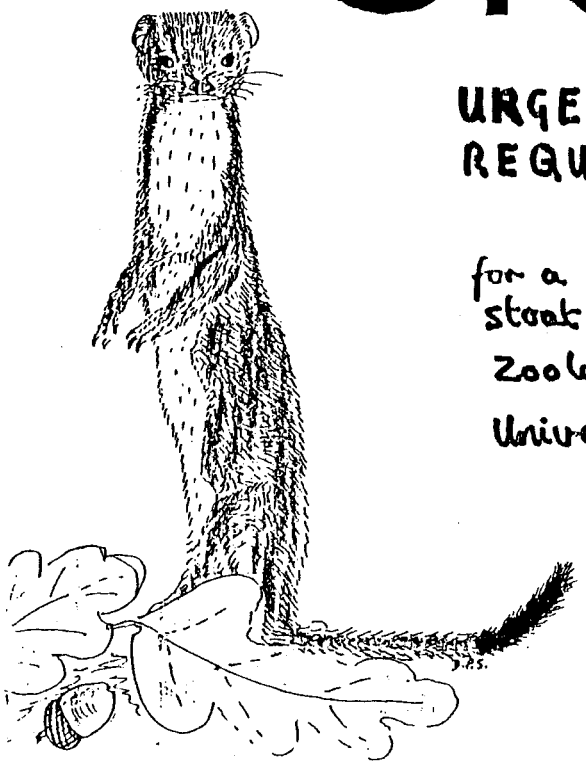
APPENDIX 2: continued:-

2:D THE POSTER USED TO SOLICIT STOAT CARCASES.

IRISH STOATS

URGENTLY REQUIRED

for a scientific study of stoat ecology at the Zoology Department University College, Cork (1982-85)



Stoats are small brown animals with a black tipped tail. The stoat found in Ireland and the Isle of Man is an endemic sub-species Mustela erminea hibernica, the Irish stoat.

These animals can be found dead from road and other accidents. Should you find one dead please put it in a plastic bag, plus a note as to the date, location and your name and address. You could deliver it to us, or freeze it and request collection.

Stoats please to:

David Patrick Sleeman,
Zoology Department, U.C.C.
'phone CORK 26871 ext 2411 or 2355

or local contact:

In contributing a carcase you will be participating in the quest for a better understanding of this unique mammal.

The Irish stoat is fully protected in the Irish Republic under the Wildlife Act of 1976.

APPENDIX 2:E IRISH MAMMAL ROAD CASUALTIES

from Irish Naturalists' Journal 21:544 (1985)

IRISH MAMMAL ROAD CASUALTIES

Mammal road casualties have been recognised as a useful source of information (Jahn 1959 *J. Wildl. Mgmt* **23**: 187-197, Case 1978 *Wildl. Soc. Bull.* **43**: 8-13). These casualties are known to be a major cause of mortality in certian mammal populations for example badgers *Meles meles* (L.) in England (Gallagher and Nelson 1979 *Vet. Rec.* **105**: 546-551). Such casualties have received only passing mention in Ireland. To provide some Irish data on the subject five investigators co-operated to do a road casualty survey over one year, June 1983 to May 1984.

The wild mammal species recorded are: hedgehog *Erinaceus europaeus* L., rabbit *Oryctolagus cuniculus* (L.), Irish hare *Lepus timidus hibernicus* (Bell), brown rat *Rattus norvegicus* (Berkenhout); fox *Vulpes vulpes* (L.), Irish stoat *Mustela erminea hibernica* (Thomas and Barrett-Hamilton) and badger *Meles meles* (L.). Domestic mammals are: cat *Felis catus* (Schreber), dog *Canis familiaris* L. and sheep *Ovis aries* L.

Ten mile (16.0km) stretches of road were searched in ten different areas. For the first three months all ten areas were surveyed giving a total of 100 miles (160km) per month. Thereafter distances of less than 100 miles (90 miles in September to November; 50 in December; 70 in January and February; 30 in March and April and 50 in May) were covered. The total distances surveyed per county were: 90 miles in Donegal, 150 in Cavan, 40 in Tipperary and 590 in Cork. The road counts were made once only, in daylight at speeds of up to 40mph (64kmph) from a car, occasional stops being made for closer examination of a dead mammal. Only mammals of rat size or bigger were recorded. All roads surveyed were national primary or secondary routes. They passed mainly through farmland, but also through woodland, villages and the edges of towns. In the course of the survey 152 recognisable casualties were recorded; the numbers of each species were as follows:

Hedgehog	Rabbit	Hare	Rat	Fox	Stoat	Badger	Cat	Dog	Sheep
12	41	2	59	2	3	4	25	2	2

The data indicate that the most frequent mammal killed on the roads surveyed was the brown rat, followed by the rabbit and the cat. The large figures for these species were not distorted by figures from one particular area; cats were, however, found more often near human settlements. Without traffic data, which was not collected, the usefulness of such records is limited, but it is hoped that the availability of numbers of animals killed per mile will be of use to future investigators.

The authors are endeavouring to produce more detailed data on casualties in hedgehogs (PS), stoats (DPS) and badgers (PGS).

We would like to thank our fellow surveyors P. A. Byrne and A. Ní Shuilleabhan.

Department of Zoology, University College, Cork — D. P. SLEEMAN
Ballykenneally, Ballymacoda, Co. Cork — P. SMIDDY
Clyda Cottage, Lavally, Mallow, Co. Cork — P. G. SWEENEY

APPENDIX 3

A: Museum skin coat colours [Skins examined in the National M
ar

Museum No	Sex	Ventral Coat Pattern	County	Map Reference [10km grid]
British Museum (N.H.)				
39.7.60	/	C	/	/
69.1133	♂	C	Antrim	Massereene Park
69.1138	♂	C	Antrim	Crumlin D17
11.1.3.201	♂	C	Fermanagh	Colebrooke H34
1939.1847	♂	C	Antrim	Glenarm D31
691136	♂	C	Antrim	Crumlin D17
1848	♂	C	Antrim	D31
1854	♀	C	Armagh	H85
11.1.3.200	♂	C	Fermanagh	Colebrooke H34
1851	♀	C	Antrim	D31
519	♂	B	Waterford	Cappagh X09
1939.1852	♂	C	Waterford	Cappagh X09
512	♂	C	Waterford	Cappagh X09
69.1135	♀	C	?	?
532	/	B	?	?
11.1.3.203	♂	C	Wexford	S71
338	♀	C	Meath	?
343	♀	B	Wexford	X72
93.1.61	♂	B	Galway	L73
69.11.32	♂	B	Antrim	?
69.11.34	♂	B	Antrim	D17
11.1.3.199	♂	B	Fermanagh	H34
1849	♂	B	Antrim	D31
None	♀	B	Fermanagh	H24
1939.1853	♂	B	Donegal	G57
1939.1850	♂	B	Antrim	D31
*95.4.51	♂	C	Fermanagh	H24
69.1131	♀	C	Antrim	?
69.1137	♀	C	Antrim	D17
69.1139	♀	C	Antrim	D17
None	♀	A	Wicklow	O21
None	♂	A	Fermanagh	H34
*Type				
Ulster Museum (Belfast)				
M426026	♂	B	Donegal	C11
None	♂	C	Antrim	Ballymeana D00
M426019	♀	C	Antrim	D31
M426016	?	C	?	?
M426018	♂	C	Antrim	D00
569-1963	♂	C	?	Craigantlet
M426017	♀	C	Antrim	J17
M426021	?	C	?	?
M426008	?	B	Down	J47
M426020	♂	B	Antrim	D40

APPENDIX 3

B: Museum specimens donated during the study

Skins: One hundred and thirty three flat skins collected in Ireland donated to the National Museum of Ireland (Dublin) Museum No NMI 79.1985
Three flat skins collected on the Isle of Man donated to the Manx Museum, Douglas, I.O.M.

Bones: Twenty seven Irish stoat skulls collected in Ireland (in case of males accompanied by bacula) donated to the National Museum of Ireland; Museum No NMI 44.1986
A skull and baculum of British stoats donated to the Zoology Museum, University College, Cork Acc.Nos UCC86 01395 and UCC86 01396.

APPENDIX 4

Reproductive aging results compared with skull aging results.
The reproductive estimates here do not follow the scheme as in Fig 11.
Post-orbital ratio estimates based on figures from Grue & King (1984).

STOAT				SKULL		
No	Sex	Month	Reproductive Age estimate	Sutures Visiable	Post-Orbital Ratio	Skull age estimate
5	♂	January	Young	No	1.00	Young
6	♂	Februry	Adult	No	1.21	Adult
16	♂	March	Adult	No	1.30	Adult
18	♂	March	Young	No	1.07	Young
20	♀	March	Adult{pregnant}	No	1.15	Young
34	♂	July	Young	No	1.10	Young
37	♂	August	Young	No	1.07	Young
38	♂	August	Young	No	1.05	Young
39	♂	September	Young	No	1.00	Young
49	♂	October	Young	No	1.00	Young
50	♂	June	Adult	No	1.25	Adult
51	♀	September	Young	No	1.00	Young
57	♂	November	Young	No	1.10	Young
59	♂	December	Young	No	1.00	Young
60	♀	December	Young	No	1.00	Young
64	♀	August	Young	No	0.91	Young
65	♂	March	Young	No	1.02	Young
66	♂	August	Young	No	1.05	Young
69	♂	November	Young	No	1.05	Young
70	♂	March	Adult	No	1.15	Adult
71	♂	March	Adult	No	1.15	Adult
78	♂	?	Young	No	1.13	Young
81	♂	April	Adult	No	1.19	Adult
90	♂	May	Adult	No	1.27	Adult
95	♂	May	Adult	No	1.15	Adult
104	♂	June	Young	Yes	0.93	Young
115	♂	June	Young	Yes	0.90	Young
120	♀	August	Young	Yes	0.84	Young
140	♀	October	Young	No	1.00	Young
146	♀	November	Young	No	0.93	Young
150	♂	March	Young	No	0.98	Young
151	♂	March	Adult	No	1.10	Adult
152	♂	March	Adult	No	1.19	Adult
156	♂	April	Adult	No	1.10	Adult
163	♂	April	Young	Yes	0.78	Young
164	♂	April	Adult	No	1.16	Adult
176	♂	May	Adult	No	1.18	Adult
184	♀	May	Adult	No	1.10	Adult
193	♂	July	Young	Yes	0.97	Young
198	♀	June	Young	No	1.00	Young
199	♀	June	Young	No	0.78	Young

APPENDIX 5 : Form

A: Chi-square tests of young and adult stoats

MALES

Weight	Head-and-Body	Tail	Hind foot	Ear
24.02	0.83	2.06	0.20	0.03

Total: 27.14 (df=4) significant difference at $p < 0.001$
Without weight : 3.12 (df=3) not significantly different at $p < 0.50$

FEMALES

1.37	0.12	0.13	.00	.00

Total: 1.62 (df=4) no significant difference at $p < 0.80$
Without weight : 0.25 (df=3) no significant difference at $p < 0.99$

SKULLS

MALES

Mandible length	Condylobasal length	Zygomatic Width
0.013	0.062	0.053

Total: 0.072 (df=2) not significantly different at $0.80 < p < 0.50$

FEMALES

0.011	0.340	0.300

Total: 0.651 (df=2) not significantly different at $0.08 < p < 0.50$

APPENDIX 5 continued;-

B: Sexual Dimorphism [D] for Irish stoats

	Adult	Young
Head-and-body	19.3	15.6
Tail	36.2	24.0
Hind foot	22.4	15.3
Mandible length	18.6	18.6
Condylobasal length	15.7	22.3
Zygomatic width	22.5	31.5

C: Size of British stoats, weasels and stoats from the Isle of Man [Head-and-body length]

England : Weasels (Sussex: data from King 1971)

	mean	range	n
Males	204	175-219	34
Females	180	172-192	20

Stoats (Suffolk & Hants: data from Gallwey & Hazelwood coll. B.M.(N.H.)

Males	284	265-306	13
Females	249	241-257	2

Scotland: Weasels (Aberdeenshire: data from Moors 1974)

Males	210	185-229	54
Females	174	167-180	8

Stoats (Perthshire: data from B.M.(N.H.)

Males	274	264-284	9
Females	256	220-261	4

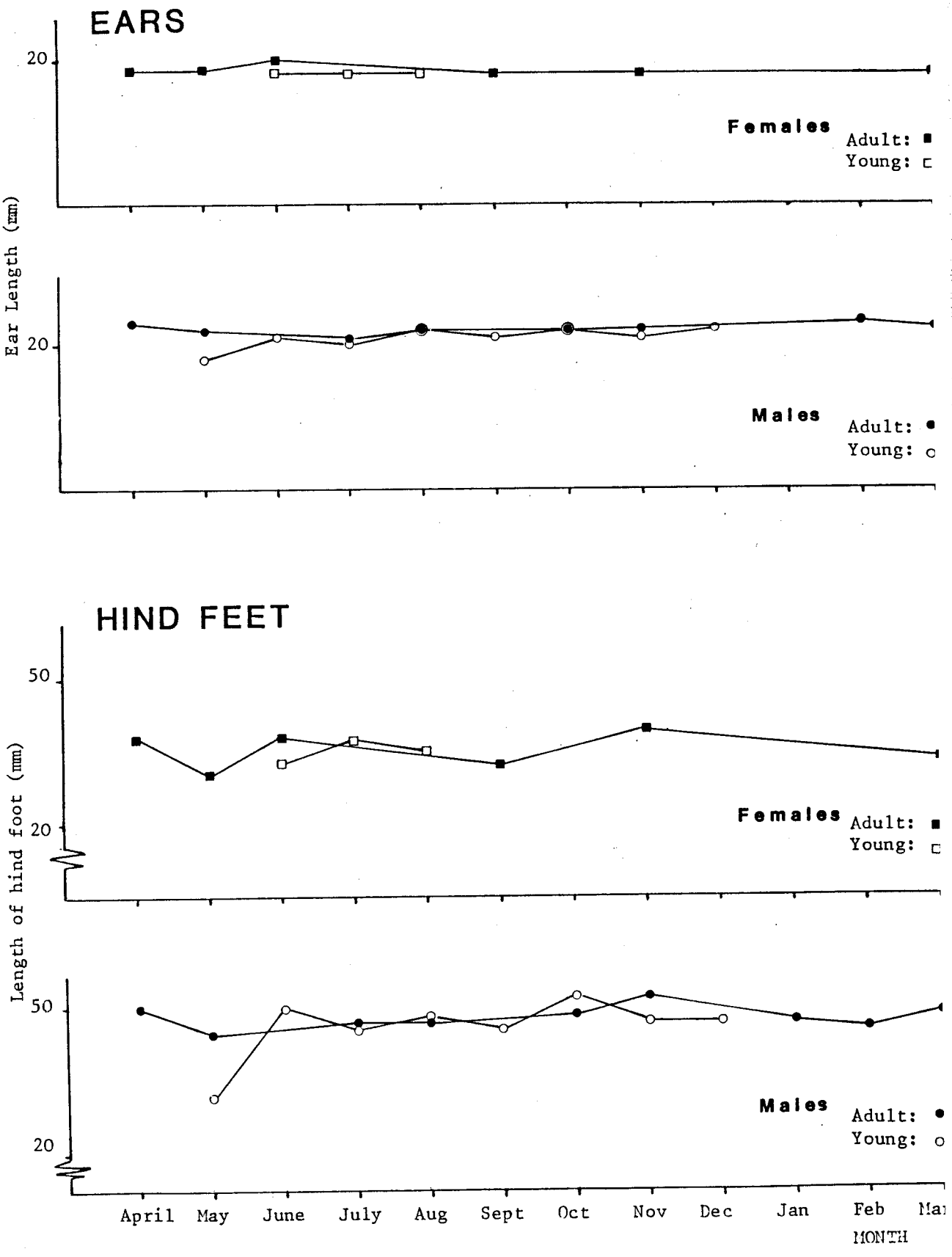
Isle of Man: Stoats (Data from this study and B.M.(N.H.)

Males	262	232-290	3
Females	226	223-232	3

D: Adult male Irish stoats from woodland habitat in vole and non-vole areas south of the Ballynalacken line (insufficent data available for females)

	Mean Head-and-body	Mean Weight
Adult males from non-vole areas	283.4 (s.d.=14)	366.0 (s.d.=59)
Adult males from vole areas	284.5 (s.d.=15)	351.4 (s.d.=53)

APPENDIX 5E FIGURE OF MEAN LENGTH OF STOATS' EARS AND HIND FEET (ADULTS)



APPENDIX 5:-continued

E: χ^2 Tests for % of ventral coat pattern of A, B and C.

Ulster/Connaught	0.15	$0.80 > p > 0.50$
Ulster/Leinster	1.16	$0.50 > P > 0.20$
Ulster/Munster	16.50	$p < 0.001$
Connaught/Leinster	4.89	$0.05 > p > 0.02$
Connaught/Munster	6.71	$0.02 > p > 0.01$
Leinster/Munster	1.07	$0.20 > p > 0.10$

APPENDIX 6

A: Frequency distributions of lice ticks and fleas on one hundred and twenty two Irish stoats.

	Lice	Ticks	Fleas
Mean infestation	5	19.7	1.4
Variance	1975.3	1777.3	2418.8

APPENDIX 6:B RECORDS OF FLEAS (SIPHONAPTERA) FROM IRISH STOATS

from Irish Naturalists' Journal 22: 257-258 (1987)

RECORDS OF FLEAS (SIPHONAPTERA) FROM IRISH STOATS

The Irish stoat *Mustela erminea hibernica* (Thomas and Barrett-Hamilton 1895) is confined to Ireland and the Isle of Man. From 1981 to 1985 a total of 58 identifiable fleas were recovered from this subspecies. The number, sex, location (with 10km grid reference) and date (month and year) of the flea species recorded are listed below. Details of the distribution of these fleas and other ectoparasites on the stoats will be published elsewhere. New county records are indicated by an asterisk.

Spilopsyllus cuniculi (Dale):— 1♀ Banteer, Co Cork W39 March 1985.

Ctenophthalmus nobilis (Rothschild):— 1♀ Kinnegad, Co Westmeath N54 May 1981 (same stoat as under *D. gallinulae*); 1♂ Killarney, Co Kerry V99 July 1981 3♂♂ and 5♀♀ Cloghroe, Co Cork W56 June 1982; 1 unsexed due to damage Ballydesmond, Co Cork R10 August 1982; 1♂ Farran, Co Cork W46 March 1983; 1♂ Gort, Co Galway M40 March 1983; 1 unsexed due to damage Lavally, Co Cork W59 November 1983; 2♀♀ Castleisland, Co Kerry R00 October 1983; 1♀ Ballynatray, Co Waterford X08 june 1984; 1♀ Glen Poer, Co Waterford S32 August 1984; 1♂ Millstreet, Co Cork W28 March 1985; 2♂♂ Kilmacsimon, Co Cork W55 April 1985; 1♀ Fota, Co Cork W77 May 1985; 1♂ Ballincollig, Co Cork W67 June 1985; 1♂ and 4♀♀ Fota, Co Cork W77 June 1985 (same stoat as under *N. fasciatus*); 2♂♂ and 5♀♀ Fota, Co Cork W77 August 1985; 1♀ Rigsdale, Co Cork W56 October 1985.

Dasypsyllus gallinulae (Dale):— 2♂♂ Burncourt, Co Tipperary R91 April 1985;* 1♀ Kinnegad, Co Westmeath N54 May 1981 (same stoat as under *C. nobilis*).

Nosopsyllus fasciatus (Bosc):— *1♀ Inch Island, Co Donegal C32 August 1983; 1♀ Kinsalebeg, Co Waterford X18 May 1984; 1♂ Leamlara, Co Cork W87 June 1984; 1♂ Killarney, Co Kerry V98 July 1984; 2♀♀ Ballybraher, Co Cork W96 July 1984; 1♀ Bridgetown, Co Waterford S90 October 1984; 1♀ Dundrum, Co Tipperary R94 November 1984; 1♂ and 1♀ Riverstick, Co Cork W65 February 1985; 7♀♀ Fota, Co Cork W77 June 1985 (same stoat as under *C. nobilis*); 1♀ Glen Maye, Isle of Man SC28 July 1982. This flea has previously been recorded from the Isle of Man (Roberts, C. J., 1975 *Entomologist's Gaz.* **26**: 139-144).

All the flea species listed above have previously been recorded on stoats in Ireland (Classens, A. J. M. and O'Rourke, P. J., 1966 *Proc. R. Ir. Acad.* **64**: 413-463, Fairley, J. S., 1971 *Ir. Nat. J.* **17**: 49-57, Fairley, J. S., and Foster, R., 1979 *Entomologist's Gaz.* **30**: 56-58). The flea fauna of the stoat is strikingly similar to the flea fauna of the common rat (*Rattus norvegicus* (Berkenhout)) here. The most frequent species being *C. nobilis* followed by *N. fasciatus* on common rats (Classens and O'Rourke *op. cit.*, Sleeman and Kelly *in prep.*) just as on the stoats referred above. This is considered to be due to the use of rats' nests by stoats.

ACKNOWLEDGEMENTS

I would like to thank those who collected the above stoats and who frequently went to heroic lengths to collect and deliver the carcases. These records are part of a study of the Irish stoat supported by the Forest and Wildlife Service.

Department of Zoology, University College, Cork D. P. SLEEMAN

APPENDIX 6:C RECORDS OF FLEAS (SIPHONAPTERA) FROM COMMON RATS IN IRELAND.

from Irish Naturalists' Journal 22:256-257 (1987)

RECORDS OF FLEAS (SIPHONAPTERA) FROM COMMON RATS IN IRELAND

Rat fleas are important because they are often vectors of disease. Fleas are a relatively well studied group in Ireland, though, surprisingly those on rats have received little attention. Two species *Nosopsyllus fasciatus* (Bosc) and *Ctenophthalmus nobilis* (Rothschild) have been recorded from the common rat *Rattus norvegicus* (Berkenhout) in Ireland (e.g. O'Mahony, E. 1947 *Ir. Nat. J.* 9: 78–79; Claassens, A. J. M. & O'Rourke, F. J. 1966 *Proc. R. Ir. Acad.* 64B: 413–463). Records of flea species from common rats collected from 1964 to 1985 are listed below. Each record includes the number and sex of the fleas, the location (with 10km grid reference) and, if available, host details and date (month and year). The records refer either to groups of rats (pooled data from Kelly 1969, B.Sc Dissertation, University College, Cork unpublished) or to individuals. The majority of these individuals were trapped incidentally in Fenn traps set for stoats *Mustela erminea* L. by one of us (DPS).

Hystrichopsylla talpae Curtis:—2 ♂♂ and 4 ♀♀ on 10 rats Kilmallock, Co Limerick R62 September 1964; 1 ♂ on ♂ rat Cork City W77 February 1983 (same rat as under *C.nobilis*).

Ctenophthalmus nobilis (Rothschild):—14 ♂♂ and 36 ♀♀ on 10 rats Kilmallock, Co Limerick (same rats as under *H.t.talpae* & *N.fasciatus*); 7 ♂♂ and 18 ♀♀ on 8 rats Warrenscourt, Co Cork W36 July 1966 (same rats as under *N.fasciatus*); 7 ♂♂ and 36 ♀♀ on 16 rats Killorglin, Co Kerry V79 July 1969 (same rats as under *N.fasciatus*) 3 ♂♂ and 2 ♀♀ on 5 rats Cork Airport W66 July 1969 (same rats as under *N.fasciatus*); 4 ♂♂ on ♂ rat Derry C41 February 1982. The following records are from Ardfield, Co Cork W33: 6 ♂♂ and 15 ♀♀ on 3 young rats from a nest July 1982; 1 ♀ on ♂ rat August 1982 (same rat as under *N.fasciatus*); 4 ♂♂ 4 ♀♀ on ♂ rat November 1982 (same rat as under *N.fasciatus*); 6 ♂♂ on ♀ rat April 1983 (same rat as under *N.fasciatus*); 1 ♀ on ♀ rat April 1983; 1 ♂ on ♂ rat November 1983; 1 ♂ and 2♀♀ on ♂ rat November 1983. 2 ♂♂ on 3 ♀♀ on ♀ rat Cape Clear Island, Co Cork V92 August 1983; 1 ♀ from young rat from nest Dunmanway, Co Cork W25 April 1983 (same rat as under *N.fasciatus*); 1 ♀ on ♂ rat Cork City W77 (same rat as under *H.t.talpae*); 1 ♀ on ♀ rat Cork City W77 February 1983; 2 ♂♂ on 5 ♀♀ on ♀ rat Cork W77 February 1983.

Nosopsyllus fasciatus Bosc:—2 ♂♂ and 1 ♀ on rats Kilmollock (same rats as under *H.t.talpae* & *C.nobilis*); 1 ♂ on rats Killorglin (same rats as under *C.nobilis*); 2 ♂♂ and 1 ♀ on rats Warrenscourt (same rats as under *C.nobilis*); 2 ♂♂ and 1 ♀ on rats Cork Airport (same as under *C.nobilis*). The following records are from Ardfield, Co. Cork W33: 12 ♂♂ and 12 ♀♀ on ♂ rat November 1982 (same rat as under *C.nibilis*); 2 ♂♂ and 1 ♀ on ♀ rat April 1983 (same as under *C.nobilis*); 4 ♂♂ and 4 ♀♀ on ♀ rat April 1983 (same rat as under *C.nobilis*); 1 ♂ and 1 ♀ on ♂ rat November 1983 (same rat as under *C.nobilis*); 1 ♀ on ♂ rat August 1982. 1 ♂ on young rat from nest Dunmanway, Co Cork (same rat as under *C.nobilis*); 5 ♀♀ on ♀ rat Cape Clear, Co Cork V92 August 1983 (same rat as under *C.nobilis*) 1 ♂ and 1 ♀ on ♂ rat Castlefreke, Co Cork W33 April 1985.

The records of *H.t.talpae* represent a new Irish host record. There is evidence to suggest that the pygmy shrew *Sorex minutus* L. is the principle host of this flea in Ireland (Grainger, J. P. & Fairley, J. S. 1978 *J. Zool. Lond.* 186: 109–141) however there are also many records from woodmice and house mice (e.g. O'Mahony, E. 1939 *Entomologist's mon. Mag.* 75: 124–126, Fairley, J. S. 1963 *Ir. Nat. J.* 14: 145–149, Sleeman, D. P. 1986 *Ir. Nat. J.* 22: 80–81). The common rat is regarded as a primary host of *N.fasciatus* but small rodents (mice and voles) are regarded as primary hosts of *C.nobilis* (Smit, F. G. A. M. 1957 *Entomologist's Gaz.* 8: 45–75). The above records indicate that *C.nobilis* is much more frequent than *N.fasciatus* on rats here, as has been pointed out by Claassens & Rourke (*op. cit.*). Common rats must therefore be regarded as a primary host of *C.nobilis*.

Acknowledgements: We wish to thank those who trapped the rats in Kilmallock, Warrenscourt and Killorglin many years ago, namely T. O'Donnell, C. Duggan and M. V. Verling. We are indebted to the landowners for permission to trap on their land. Finally we are particularly grateful to K. G. M. Bond for, once again, patiently checking our records with his usual precision.

D. P. SLEEMAN and T. C.KELLY

Department of Zoology,
University College, Cork.

APPENDIX 6:-continued

D: Ectoparasites of 29 common rats (*Rattus norvegicus*) incidentally trapped during Fenn trapping for stoats.

Mites	Fleas			Lice	Ticks
	Ctenopthalmus nobilis	*Nosopsyllus fasciatus*	*Hystrichopsylla talpae*	*Polyplax spinulosa*	*Ixodes ricinus*
46	8	24	1	4	2
4	5	1		1	10
1	1	2		1	57
156	7	8		1	25
1	1	2			1
40	31				5
3	1				1
1	6				
3	1				
7	3				
5	5				
2	4				
2	1				
	1				
	1				
271	76	66	1	7	101

APPENDIX 6: continued:-

E: Skulls of Irish carnivores (not stoats) examined for nematode damage

No	Sex	Age	Damage	Original Location	Present Location
MINK					
MO1	?	Juv	None	West Cork	University College, Cork Zoology Dept. Museum.
MO2	?	"	"	" "	" " "
AT2	♂	?	"	" "	" " "
AT3	♀	?	"	" "	" " "
MARTEN					
PO'S 2	♂	?	None	Co Clare	University College, Cork Zoology Dept. Museum.
PO'S 3	?	?	None	" "	" " " " "
OTTER					
OT6	♂	Young	None	Co Cork	" " " " "

APPENDIX 7

A: Weights of baculum
Illustrated in Figure 9 and not listed here.

B: Weights of ovaries and uteri
Illustrated in Figure 10.
Overies weighted from 0.017-0.090g
Uteri weighted from 0.076- 0.484g

C: Weights and condition of testes
Illustrated in Figure 8.
Testes weighted from .003-3.57g
They contained sperm March,April,May,June and August.
They were descended from Janurary to August.

D: Nipples
Numbers that were obivious and position

Stoat No	No of Nipples	Position
162	9	4 on rt 5 on left
8	12	6 on each side
96	12	6 on each side
184	9	5 on rt 4 on left
191	8	4 on each side
185	9	5 on rt 4 on left
182	7	4 on rt 3 on left
178	10	5 on each side
190	9	4 on rt 5 on left
133	10	5 on each side
51	8	4 on each side
117	10	5 on each side
60	10	5 on each side
52	10	5 on each side
76	12	6 on each side
20	12	7 on rt 5 on left
31	8	4 on each side
100	8	4 on each side
106	9	5 on rt 4 on left
168	10	6 on rt 4 on left
1	12	6 on each side

APPENDIX 8 DIET

A: Stoats' guts examined and prey remains found

No	Sex	Cause of Death	Identifiable prey remains found
4	♂	*RTA	None
6	♂	Trapped	None
8	♀	RTA	Rabbit hair
9	♂	RTA	None
10	♂	RTA	Rabbit hair and bones
11	♂	RTA	Rabbit hair
14	♂	RTA	None
15	♀	RTA	Wood mouse hair
16	♂	Trapped	None
17	♂	Trapped	Rabbit hair and bones
18	♂	Trapped	Bird (Charadiformes) feathers and bones
19	♂	RTA	Rabbit hair and bones
20	♀	Trapped	Rabbit hair and bones
21	♂	RTA	Psocid (Invertebrate)
22	♂	RTA	None
23	♂	RTA	None
24	♂	RTA	None
25	♂	RTA	Rat hairs
26	♂	RTA	Bird (Passeriformes) feathers
29	♂	RTA	Wood mouse hair feet and bones
30	♂	RTA	None
31	♀	RTA	Rabbit hair
33	♂	RTA	Wood mouse hair
35	♂	RTA	Diptera wing (Invertebrate)
37	♂	RTA	Bird (Passeriformes) feathers and bones
38	♂	RTA	Bird (Columbiformes) feathers and bones and Plecoptera (Invertebrate)
39	♂	RTA	Bird (Columbiformes) feathers and bones
41		RTA	None
43	♂	RTA	Bird (Passeriformes) feathers
44	♀	RTA	Shrew hair and bones
47	♂	RTA	None
48	♂	RTA	Shrew hair and bones
49	♂	RTA	Rat hair and bones
50	♂	RTA	None
51	♀	Trapped	Bird (Charadiformes) feathers
52	♀	RTA	Vole hair and bones
54	♂	RTA	None
55	♀	RTA	Shrew hair and bones
56	♂	RTA	None
57	♂	Trapped	None
58	♂	RTA	None
59	♂	Trapped	Bird (unidentified) feathers (sheathed)and bones
60	♀	Trapped	Shrew hair and bones

*road traffic accident

Appendix 8A continued;-

No	Sex	Cause of death	Identifiable prey remains found
61	♀	RTA	Bird (Passeriformes) feathers bones and feet
63	♂	RTA	Rat hair and bones
64	♀	RTA	Rabbit hair
65	♂	Trapped	None
66	♂	RTA	Rat hair
68	♀	RTA	Bird (Passeriformes) feather and beak
69	♂	RTA	Rabbit hair
70	♂	RTA	Rabbit hair and bones
71	♂	Predation	Rabbit hair and bones
73	♂	RTA	None
74	♂	RTA	Rat hair and bones and small stones
76	♀	RTA	None
77	♂	RTA	Stoat hair
78	♂	?	Bird (Columbiformes) feathers in sheaths
79	♂	RTA	Bird (unidentified) feathers, sheathed.
81	♂	RTA	None
82	♂	RTA	None
84	♂	RTA	None
85	♂	RTA	Rabbit hair and bones
88	♂	RTA	Rabbit hair and bones
89	♂	RTA	None
90	♂	RTA	None
94	♀	Predator	Stoat hair and bones
95	♀	?	Rat hair
96	♀	RTA	Shrew hair and bones
98	♂	RTA	Unidentified invertebrate
100	♀	RTA	Rat hair
101	?	RTA	None
102	♂	RTA	Rabbit hair and bones
103	♀	RTA	None
104	♂	RTA	Bird (Columbiformes) feathers and bones
106	♀	RTA	Rat hair and a small stone
107	♂	RTA	Rabbit hair
113	♀	RTA	Shrew hair and bones
114	♂	RTA	None
116	♂	RTA	Rat hair and small stones
117	♀	RTA	None
119	♀	RTA	Rabbit hair
120	♀	Predator	Shrew hair
121	♂	Predator	Rabbit hair and bones
124	♂	RTA	Rabbit hair
125	♀	RTA	Shrew hair and bones
126	♀	RTA	Shrew hair
128	♀	RTA	Rabbit hair
130	♀	RTA	Shrew hair
131	♀	RTA	None
133	♀	RTA	Vole hair
134	♂	RTA	None
135	♂	RTA	Rabbit hair and bones
136	♂	RTA	Shrew hair and small stones

APPENDIX 8A continued:-

No	Sex	Cause of death	Identifiable prey remains
137	♀	RTA	Rat hair
138	♂	RTA	Rat hair
139	♂	RTA	Shrew hair and bones
140	♀	RTA	None
141	♀	RTA	None
142	♂	RTA	Rabbit hair
143	♀	RTA	Shrew hair
144	♂	RTA	None
145	♂	RTA	None
146	♀	Predator	None
148	♂	RTA	None
149	♂	RTA	None ,except a tick Ixodes hexagonus
150	♂	RTA	None
151	♂	RTA	Rabbit hair
152	♂	RTA	None
153	♂	RTA	Shrew hair
154	♂	RTA	None
155	♂	RTA	Shrew hair
156	♂	Trapped	Shrew hair
158	♂	RTA	Bird (Passeriformes) feathers and bones
159	♀	RTA	None, one small stone, carrying a Juv´ rabbit
161	♂	RTA	Rabbit hair, bones and 72 small stones
163	♂	Predator	Rabbit hair
164	♂	RTA	Rabbit hair and bones
165	♂	RTA	Vole hair
166	♂	RTA	None
167	♀	Predator	Rabbit hair
169	♂	RTA	None
171	♂	RTA	Wood mouse
176	♂	RTA	None
178	♀	RTA	Shrew hair
179	♂	RTA	Shrew hair and bones
180	♀	RTA	Shrew hair and bones
181	♂	RTA	Rabbit hair
183	♀	RTA	Shrew hair and bone
184	♀	RTA	None
185	♀	RTA	Wood mouse hair
188	♂	RTA	Vole hair bones and feet
189	♂	RTA	Shrew hair and bird (Passeriformes) feathers
190	♀	RTA	Rat hair and bones
191	♀	RTA	Rabbit and shrew hair
192	♂	RTA	Bird (Passeriformes) feathers,sheathed and 3 small stones
193	♂	Predator	Shrew hair and bones and bird (Charadiformes) feathers
196	♂	RTA	Rabbit hair
200	♀	?	Shrew hair

APPENDIX B

B: Results of studies of the food habits of British stoats and weasels

STOATS	Investigators			
	Day (1968)	Potts & & Vickerman (1974)	Tapper (1976)	Alcock & Warsop
No of Stoats	168	31	46	30
Lagomorphs	28%	39%	56%	50%
Birds	33%	13%	25%	3%
Mice & Voles	18%	25%	7%	40%
Rats	3%	3%	0%	0%
Shrews	0%	0%	0%	0%

WEASELS	Investigators as above			
No of Weasels	152 [guts & scats]	186	151	8
Lagomorphs	19%	12%	8%	0%
Birds	14%	14%	27%	0%
Mice & Voles	43%	55%	47%	100%
Rats	0%	0%	0%	0%

WEASELS (continued)	Investigators Moors (1975)	King (1980)	Walker (1972)
No of Weasels	50	215 (scats)	28
Lagomorphs	17%	.5%	3.5%
Birds	19%	17%	11%
Mice & Voles	46%	76%	71%
Rats	0%	0%	14%

APPENDIX 9

MUSTELID TISSUES (LEG,LIVER AND TESTES) COLLECTED
FOR ELECTROPHORISIS DURING THE STUDY

Tissues from 101 Irish stoats from Ireland and the Isle of Man.
" " " " 8 British stoats from England.
" " " " 8 British weasels " " " " .
" " " " 4 mink from Ireland.
" " " " 1 otter from Ireland
" " " " 3 pine marten from Ireland.
" " " " 1 domestic ferret from Ireland.

APPENDIX 10 TRAPPING RECORDS

A : FENN TRAPPING RECORDS FROM VARIOUS LOCATIONS

Month & Year	Location with 10 km grid refer'	Trap Nights	Habitats trapped	Bait(s)	Captures	Concurrent small mammal trapping results/ or status of voles at site
February 1983	Fort William Cork W77	60	Woodland	Rabbit's guts	1 Stoat(♂) 5 Rat	50 snap trap nights - 2 Woodmice.
March 1983	Farran Co Cork W46	8	Woodland	None	4 Stoats (3 ♂♂, 1 ♀)	no voles see Smal & Fairley (1984)
April 1983	Ardfield Co Cork W33	60	Farmland	Cat food	1 Cat 3 Rat	20 snap trap nights - no captures - due to rats ?
June 1983	Fort William Cork W77	56	Woodland	Rabbit's guts	3 Rats	none
June 1983	Ardfield Co Cork W33	50	Farmland	Rabbit's guts	2 Rats	50 snap trap nights - 1 Woodmouse.
July 1983	Ardfield Co Cork W33	40	Farmland	Rabbit's guts	2 Cats 2 Rats	73 snap trap nights - 5 Woodmice - 1 Pygmy shrew
October 1983	Ardfield Co Cork W33	80	Farmland	Cat food	4 Rats	none
November 1983	Farran Co Cork W77	1	Woodland	None	1 Stoat(♂)	no voles see Smal & Fairley (1984)
December 1983	Farran Co Cork	2	Woodland	None	2 Stoats (♂ & ♀)	" " " " " " " "
April 1985	Castlefreke Co Cork W33	102	Woodland	Rabbit's guts	6 Rats	none (see Smiddy in prep)
TOTALS		459 Fenn trap nights			8 Stoats 25 Rats 3 Cats	193 snap trap nights

B : SNAP TRAPPING RECORDS FOR SMALL MAMMALS AT FOTA 1985

Month & duration	Trap Nights	Habitats Trapped	Captures
January (6 days)	84	Woodland Marsh	28 Woodmice
April (6 days)	64	Woodland Hedges	15 Woodmice
November (7 days)	58	Woodland	13 Woodmice
TOTALS	206		56 Woodmice

APPENDIX 10 - continued

C : LIVE TRAPPING AT FOTA ESTATE 1985

Month & duration	Trap Nights	Approximate number of traps used	Habitats trapped	Bait(s)	Captures	Approximate area trapped (in hectares)	Notes
January (9 days)	319	40	Woodland Pasture Hedges Marsh	- Cat food - Rabbit's guts	9 Woodmice	350	-traps in grid.
February (6 days)	219	40	Woodland Hedges Marsh Wildlife Pk.	- Rabbit's guts	1 Stoat (escaped) 6 Woodmice	400	- grid abandoned
April (11 days)	329	34	Woodland Wildlife Pk.	- Cat food - Stoat anal scent (♂)	1 Stoat (No 2, ♀) twice 14 Woodmice 1 Rat	300	- stoat trapped to anal scent bait w'mouse & rat to same bait.
May (11 days)	298	29	Woodland Wildlife Pk.	- Rabbit's guts - Stoat anal scent (♂ & ♀)	1 Stoat (No 3, ♀) 12 Woodmice 1 Rat	420	- stoat radio tagged counter weights fitted
August (7 days)	117	17	Woodland Wildlife Pk.	- Rabbit's guts - Stoat anal scent (♂ & ♀)	1 Stoat (No 4, ♀)	70	- stoat radio tagged.
September (4 days)	76	19	Woodland Wildlife Pk. Hedges	- Rabbit's guts - Stoat anal scent (♀)	2 Rats	38	
October (12 days)	164	14	Woodland Wildlife Pk.	- Stoat anal scent (♂)	1 Stoat (No 5, ♀)	75	- stoat radio tagged.
November (11 days)	209	19	Woodland Wildlife Pk.	- Cat food - Stoat anal scent (♀)	1 Stoat (No 6, ♂) 4 Rats 3 Woodmice	500	- first ♂ stoat w'mice & rat to stoat scent bait
December (5 days)	50	10	Woodland	- Stoat anal scent (♂)	1 Rat	46	- attempt to trap remaining tagged stoats
Totals 76 days	1781	trap nights			9 Rats 44 Woodmice 6 Stoats		

APPENDIX 11. Activity and habitat utilisation results.

A: Incidental observations from stoat records

- Records of sighting of stoats carrying prey

  Feburary 1984 - mouse in mouth.

  April 1984 - mouse in mouth.

  December 1984 - unknown prey in mouth.

- Records from the Irish Biological records centre

  The total number of records examined was 701 of which over half (356) had useful habitat descriptions. Many of the 345 records without any useful habitat notes did mention a stone wall, or road, on which the animal was seen. Many of the records came from a forestry faunal survey done in 1969 which may have biased the data in favour of woodland. Some of the records are of special interest. For example from the Shannon Airport lagoon in 1976 (Shore) and a record of a stoat swimming in Glandore Harbour in July 1971. Records were notably frequent from shore habitat in the Burren, Co Clare. There were also some high altitude records from Co Wicklow.

B: Double-sided tape tube results

In a brief trial, two weeks, in June 1984 the possibility of using PVC piping to detect stoat habitat utilisation was investigated. The study area was a 2 acre site of woodland and pasture at Fota. Stoats were present on the site, two were seen during the trial and one was caught later near the site. Three different diameters of tubing were used: 4.5cm, 6.0cm and 6.5cm. Fifteen 10cm lenghts of each type of tube were deployed on likely animal trails, some were placed up to .5m off the ground. The tubes were baited by a smear of fishy cat food.

Identifiable guard hairs were found in 8 of the 45 tubes. Of these 6 (wood mouse and red squirrel) were found in the 6.0cm diameter tubes and 3 (wood mouse and an unidentified ungulate) were found in the 4.5cm tubes. No identifiable hairs were found in the 6.5cm tubes and no stoat hairs were found. All bait was taken in 3 days. Signs of molluscs and insects were common in the tubes.

Tape tubes proved unsuccessful in detecting stoats. However 6cm tubes could provide a low cost, non labour intensive small mammal monitoring system. It should be noted that brown rats, squirrels, and weasels have been detected using 3cm tubing (Dickman 1983).

APPENDIX 11:-continued

B: TAPE TUBE RESULTS

PVC piping with double sided adhesive tape on the inside has successfully been used to detect small mammals in Australia (Suckling 1978) and Britain (Dickman 1984; G.B.Corbet pers.comm.). Usually 10cm lenghts of 3cm wide piping is used and guard hairs are identified using the keys of Day (1966) or photographs of Debrot ,Mermod,Fivaz and Weber (1984) or both .Tubes are usually baited with insect pupa or grain. In a brief trial in June 1984 the possibility of applying this technique to detect stoats was investigated at Fota Estate.

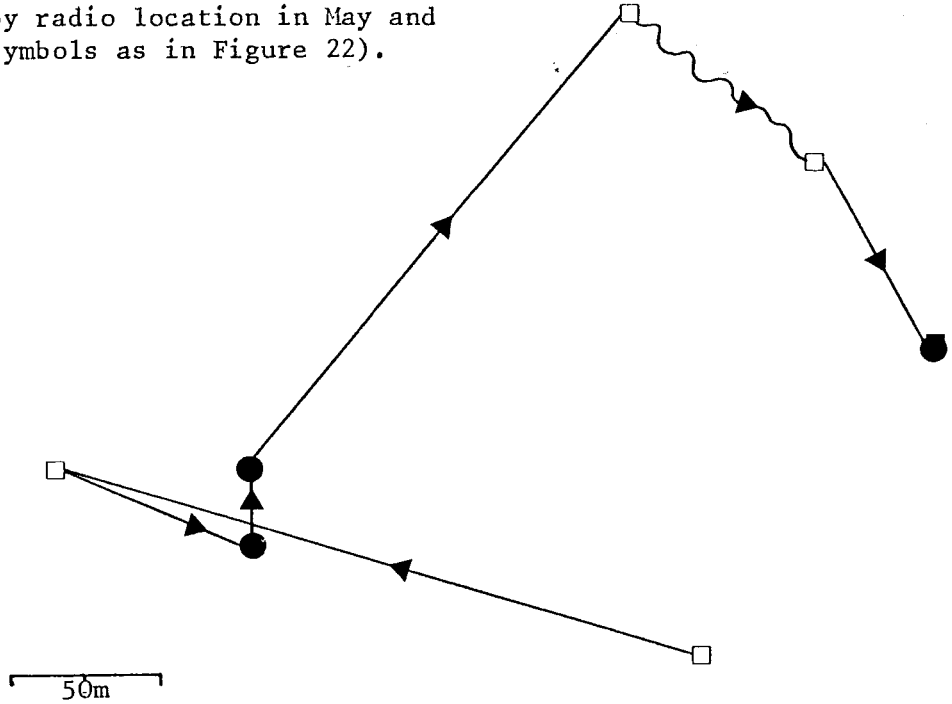
The study area was a 2 acre site of woodland and pasture. Stoats were present on the site, tweo were seen during the trial, and were later trapped nearby. Three different diameters of tubing were used; 4.5cm 6.0cm and 6.5cm. Fifteen 10cm lenghts of each type of tube were depolyed at various stations throughout the woodland and pasture. All were placed on likely animal trails, some were placed up to .5m off the ground. The tubes were baited by a smear of fishy cat food.

Identifiable guard hairs were found in 8 of the 45 tubes. Of these 6 (woodmouse and red squirrel) were found in the 6.0 diameter tubes and 3 (woodmouse and an unidentified ungulate) were found in the 4.5cm tubes. No identifiable hairs were found in the 6.5cm tubes and no stoat guard hairs were found. All the bait was taken in 3 days. Signs of molluscs and insect remains were common in the tubes.

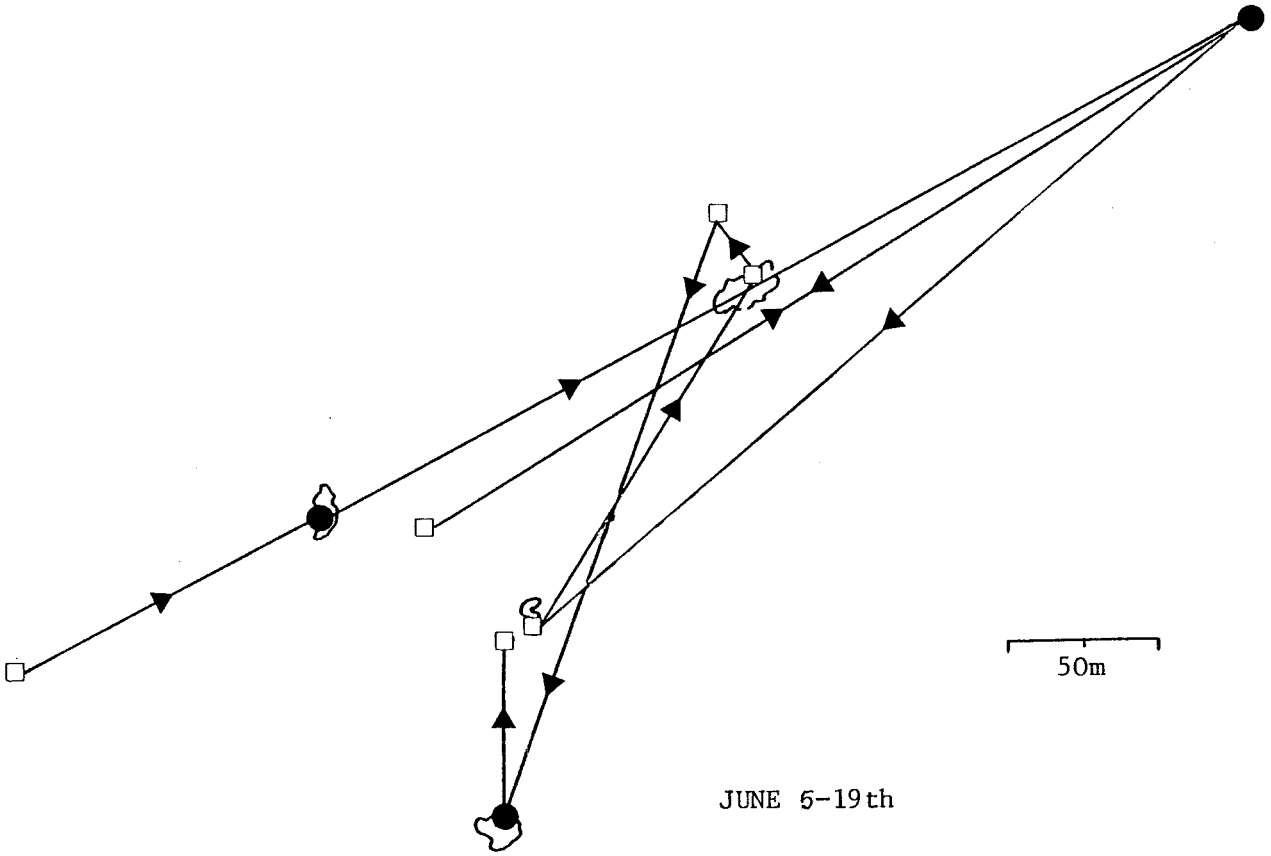
Tape tubes proved unsuccessful in detecting stoats, however the did detect squirrels and mice. In previous studies , for example Montgomer's (1980) study of arborality in small mammals , Longworth traps, which are both expensive and cumbersome, have been used. The tape tubes have several advantages over traps including low cost and maintainence and the absence of the need for regular visiting . The fact that red squirrels used the 6cm tubes indicates that this diameter would be useful for studies of squirrel sized mammals. However it should be noted that brown rats,grey squirrels and weasels have been detected using 3cm tubing (Dickman 1983).

Appendix 8 - Diet.

APPENDIX 11:C Movements by stoat No 3 (Sally) as revealed by radio location in May and early June (symbols as in Figure 22).



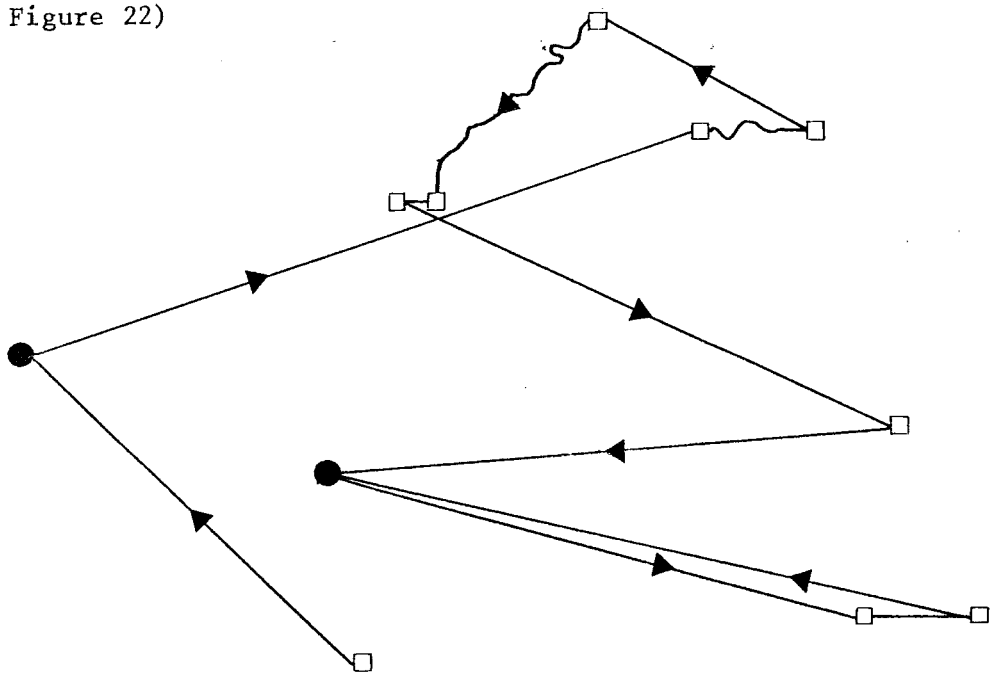
MAY 20-31st



JUNE 5-19th

APPENDIX 11:C :- continued

Movements by stoat No 3 (Sally) as revealed by radio location, July 15-20
(Symbols as in Figure 22)



JULY 15-30th

50m

APPENDIX 12:A . Scientific names of terrestrail mammal predators and prey in Britain and Ireland.

Mole Talpa europaea L.

Common shrew Sorex araneus L.

Pygmy shrew Sorex minutus L.

Water shrew Neomys fodiens (Pennant)

Rabbit Oryctolagus cuniculus (L.)

Brown hare Lepus capensis L.

Mountain hare Lepus timidus L.

Red squirrel Sciurus vulgaris L.

Grey squirrel Sciurus carolinensis Gmelin

Bank vole Clethrionomys glareolus Schreber

Field vole Microtus agrestis (L.)

Water vole Arvicola terrestris (L.)

Wood mouse Apodemus sylvaticus (L.)

Yellow-necked mouse Apodemus flavicollis (Melchiar)

Harvest mouse Micromys minutus (Pallas)

House mouse Mus domesticus ((L.)

Ship rat Rattus rattus L.

Common rat Rattus norvegicus (Berkenhaut)

Edible dormouse Glis glis (L.)

Dormouse Muscardinus arellanarius

Fox Vulpes vulpes (L.)

Pine marten Martes martes (L.)

Stoat Mustela erminea L.

Weasel Mustela miralis L.

Polecat Mustela putaris L.

Mink Mustela vison Schreber

Badger Meles meles (L.)

Wild cat Felis silvestris Schreber

Lynx Felis lynx L.

Otter Lutra lutra (L.)

Appendix 12:B

Foxes.

The size of Irish foxes has been investigated by Fairley (1970) and Fairley and Bruton (1984). Foxes from northern Ireland (and northern Scotland) are bigger than foxes from England (Kolb and Hearson (1974) and Fairley and Bruton 1984).

Mink.

The size of Irish mink has been investigated by Fairley (1980) , comparative British data (from Devon) is available in Chanin (1984) relevant data(from adult animals)is reproduced below.

	Weight*		Head and Body length	
	Mean	Range	Mean	Range
Irish males	1266	n.a.	426	n.a.
Irish females	737	n.a.	360	n.a.
English males	1232	1024-1439	397	330- 450
English females	665	559- 738	338	320- 360

n.a.:not available
* :English weights from River Otter only

Otter.

The size of Irish otters(from Co Galway)has been investigated by Fairley (1972). Comparable British data is available from Stephans 1957 (in King 1977d). All otters were assumed to be adults at weights of 4.5 kgs and over. Otters of this weight or higher are excluded from the data reproduced below :

Appendix 12:B continued

	Weight		Total length	
	mean(kg)	range	mean(cms)	range
Irish males	7.2	5.5-8.6	116	110-125
Irish females	5.1	4.6-5.9	105	101-108
British males	10.3	5.5-16.8	119	96-136
British Females	7.4	6.4-12.3	104	94-112

* most Irish otters were skinned when they were recieved , this is likely to have led to their appearing lighter than the British otters.

APPENDIX 13 IRELAND'S CARNIVOROUS MAMMALS- PROBLEMS WITH THEIR ARRIVIAL AND SURVIVAL

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IRELAND'S CARNIVOROUS MAMMALS - PROBLEMS WITH THEIR ARRIVAL AND SURVIVAL

D.P. Sleeman

Introduction

There is an understandable tendency to think of mammals from the past as moribund creatures, patiently waiting to be turned into museum exhibits. However, to understand faunas of the past, in this case Ireland's postglacial fauna, we must think of these mammals as very much alive, as they once were, with ecological requirements not unlike their present day relatives.

To facilitate this approach we will define herbivores, carnivores and animals in general in a simplified ecological perspective, and then turn our attention to Ireland's postglacial flesh eaters.

Herbivores usually have an accessible and plentiful supply of their food. Plants don't run away if eaten, so herbivores usually have little difficulty in finding food. The drawback about being a herbivore is that plant tissue is difficult to digest and of poor nutritional value (in comparison to flesh). Hence herbivores have long and complex guts, grinding teeth and other adaptations to extract nourishment from plant tissue. Flesh, on the other hand is highly nutritious and relatively easily digested. Hence, carnivores have short guts, and the flesh eating role in any habitat is highly competitive. The major problem with being a carnivore is that the original owners of the flesh are never keen on giving it up, and will run away! Therefore, we get specialisation in carnivores. One example of such specialisation is the small long and thin shape of weasels and stoats, which, although energetically inefficient, allows them to specialise in hunting small mammals down their tunnels and runways (Brown and Lasiewski, 1972).

Herbivores are the most rewarding prey for carnivores. This is because herbivores are next up in the food chains from the primary producers of biomass: plants. There must be many more herbivores than carnivores. If a rich carnivore fauna is to exist in a limited

APPENDIX 13 :- continued

area, such as an island, there will have to be an adequate herbivore prey fauna present.

Animals don't exist on their own, they interact with each other, plants and inorganic environment. If an animal's ecological requirements are not met in a particular habitat, it will not be found there. A simple example of this is on an island. A predator cannot survive on an island without suitable prey species, a herbivore without suitable plant species; and the reverse should also be true. If one finds a predator or herbivore population on an island, its presence implies the presence of suitable prey or plant species.

The Irish Situation

Ireland is such an island now. This was not always so, as it is a continental island that at some time was connected to the European mainland via Britain. Whether or not Ireland's fauna and flora arrived across such a land connection is one of the major questions at issue.

Since the last glaciation a range of animals and plants have arrived in Ireland. We know that many of the animals were introduced by man, but we also know that some animals have been here long enough to evolve into distinct Irish forms . Among the mammals there are three accepted indigenous Irish subspecies; the Irish stoat, hare and otter (Table 1). All three are arctic mammals. They are darker than the same species in Britain. Two of these distinct indigenous forms are carnivores; the stoat and otter. Other mammalian carnivores that were present in the postglacial, and still exist here are the pine marten, badger and fox. We also know from historical records and bone remains that the wild cat, brown bear and wolf survived here in postglacial times. These three species are now extinct. We know that man deliberately hunted the wolf to extinction, and the same was the likely fate of the wild cat and bear. These three extinct predators provide examples of the problems surrounding Ireland's postglacial mammal fauna. They are only accepted as postglacial because they have been found on archaeological sites (Wijngaarden-Bakker, 1974).

APPENDIX 13 :- continued

There are, therefore, eight known postglacial Irish mammalian carnivores. This, in comparison to the ten mammalian carnivores found in Britain at the same time, is not an impoverished fauna. The two species present in Britain and absent in Ireland are the weasel Mustela nivalis L. and the polecat Mustela putorius (L.).

Given Britain's size, position and richer prey fauna, it is not unexpected that the polecat reached and survived on one island and not the other. The weasel's absence from Ireland has been termed "something of a zoogeographical mystery" by Corbet (1966). However, its absence can be explained by the fact that voles, until recently were absent from Ireland, and they are a principle part of the weasel's diet (Yalden, 1982). An interesting recent suggestion by King and Moors (1979) is that the weasel did occur here during the immediate postglacial, along with lemming, but became extinct along with the latter. We have no evidence, as yet, that weasels or lemmings ever occurred in Ireland in the postglacial. A good faunal sample from a postglacial context could solve this problem.

How did the carnivores get here? It has been speculated that some forms, the artic endemic forms in particular, might have survived the last glaciation, having crossed on an earlier landbridge. It has also been advanced that at least some of these carnivores were introduced by man. For example the wild cat, which Wijngaarden-Bakker (1974) has argued was probably accidentally introduced; or the fox and pine marten which Fairley (1975) has argued might have been introduced to be harvested for their fur. The discovery of the bones of a barbary ape in a Bronze Age context (see Woodman, this volume) shows that the idea of introduction by man may not be as far fetched as it sounds. The successful establishment of twenty two alien mammal species introduced to New Zealand by man (Gibb and Flux, 1973) shows how quickly modern man can introduce viable mammal populations to the remotest locations. However, we are not dealing with modern man in the Irish postglacial. The boats available would have been primitive. Carnivores are difficult to catch alive, handle and transport. If one is to start a viable population one has to introduce a number of animals, which indicates repeated introductions, not just an occasional introduction. Could or would Ireland's early colonizers have made the necessary journeys with such animals?

APPENDIX 13 :- continued

The possibility of some carnivores swimming or rafting into the country should also be considered, as well as a land connection, or partial land connection. All we can conclude definitely is that their journey was difficult, difficult enough to exclude other forms and that there is a probability that more than one method of transport was involved.

A more important problem, in the author's view, is how these carnivores survived after arrival? For they must have survived in order to have any likelihood of leaving remains behind. The carnivore fauna is not impoverished, yet the mammalian prey fauna certainly is (Table 1). Take for example the Irish stoat. It is smaller than stoats elsewhere and this has been ascribed to the absence of the weasel here (Hutchinson, 1959; Williamson, 1972). Given this suggestion we would expect the Irish stoat to hunt down tunnels more than stoats elsewhere. However, when we examine the list of suitable prey species we find that most are considered to have been introduced. Only three suitable mammal prey species are considered native; the Irish hare, pygmy shrew and the red squirrel.

The pygmy shrew is not believed to burrow, it tastes nasty and as a secondary consumer is in an unsuitable position in the food chain for a prey species. The Irish hare, as an adult, would be very big for a stoat to prey on, in particular for the small Irish stoat. Certainly young hares could have been prey, but they would only have been available seasonally. Red squirrels live in trees and their populations cycle erratically, which means that they would not have provided a constantly available food supply.

If we accept that the Irish stoat is ecologically adapted to, and dependant on, tunneling small mammal prey, there is a problem in explaining its survival, until man introduced suitable prey. A predator must have suitable available prey all year round, every year.

There is therefore a prey gap for the stoat in the postglacial. Were there other prey species present that we are, as yet, unaware of? Did the lemmings survive, filling this gap? As all the other eight species

of carnivores are also known to eat small mammals (to a greater or lesser extent) they too would have been affected by (and indeed affect) the prey gap. The ecological effects of this prey gap, if it did exist, would be important in any ecological reconstruction of post glacial fauna.

How are we to go about solving these problems? The comparative study of the morphology, ecology and genetics of Irish, British and European mammals is one approach. The continuing study of bone remains is another - progress in our understanding of the postglacial would be greatly helped by a good faunal assemblage from a known postglacial site. Archaeological sites have served us well, mainly, for species associated with man. Investigation of a site (or sites) of bone accumulations not interfered with by man might solve some of our problems.

A rather neglected field of investigation in this area is parasitology. If an animal is introduced to a limited area in small numbers it is probable that at least some of its parasite fauna will not come with it, or survive in the new area. Can parasites tell us anything useful about how their hosts arrived, and survived, in Ireland?

For example. It is now widely accepted that the wood mouse is not native to Ireland and was accidently introduced by man (Corbet, 1961; Fairley, 1972). The rare rodent flea, Rhadinopsylla pentacantha (Rothschild) was recently rediscovered in Ireland on a wood mouse (Sleeman, 1983). A problem with the hypothesis that the wood mouse was introduced is that it is improbable that an uncommon nest flea, rarely found on its host's body, like Rhadinopsylla, could enter the island on mice introduced by man. It is of interest that Rhadinopsylla has been recorded on two islands of the Inner Hebridies, namely Eigg and Arran (George, 1974). These islands would have been connected to the putative land connection between Scotland and Ireland (Yalden, 1982).

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THE ECOLOGY OF THE IRISH STOAT D.P.Sleeman

A list of errors occurring in the text. Minor corrections.

Page 5 Add page number and underline the a in hibernica.

Page 8 Line 2 full stop missing.

Page 11 Last line should have (1.3 & 1.4).

Page 22 Line 6 should have (1.5).

Page 31 correct distinguish and August.

Page 57 line 11 remove the asterisk and add / to Ní .

Page 59 last line Appendix 11.

Page 75 line 12 Table 4 not 5.

Page 76 Add (± SE).

Page 79 " " " " .

Page 88 Add drawn from actual specimens.

Page 89 Table 12 should be 11.

Page 124 Fig 21 should be 25.

Page 125 Appendix 12 should be 11.

Page 142 - under ±SE.

Page 144 A similar

Page 148 A total.....was.

Page 150 Appendix 6:D should be E.

Page 155 hosts

Page 158 (bottom line) many.

Page 159 line 17 insert between not and stoats ", implies that"

line 21 finish sentance with "to compete."

Page 161 line 1 missing . after hypothesis,

line 7 criticed.

Page 162 line 22 add an "is" between This and the.

Minor corrections for The Ecology of the Irish stoat :- continued.

Page 173 between of stoats

Page 197 underline Alopex lagopus and Vulpes vulpes.

Page 203 line 6 Appendix 6:E.

Page 204 line 3 study's

line 20 anomaly.

Page 207 line 2 improved

line 7 identifying

Page 210 line 17 reported

Page 211 line 19 underline Mustela vison.

last line nineteen.

Page 212 line 1 Ní

line 17 towards

line 11 underline Ardea cinerea.

Page 213 involving

Page 214 line 2 regarded.

Page 215 "definite" and "Irish".

Page 216 line 19 morphological

line 21 intermediate

Page 220 line 10 thrive

line 14 devide thenit to them it.